United States
Department of
Agriculture

Forest Service

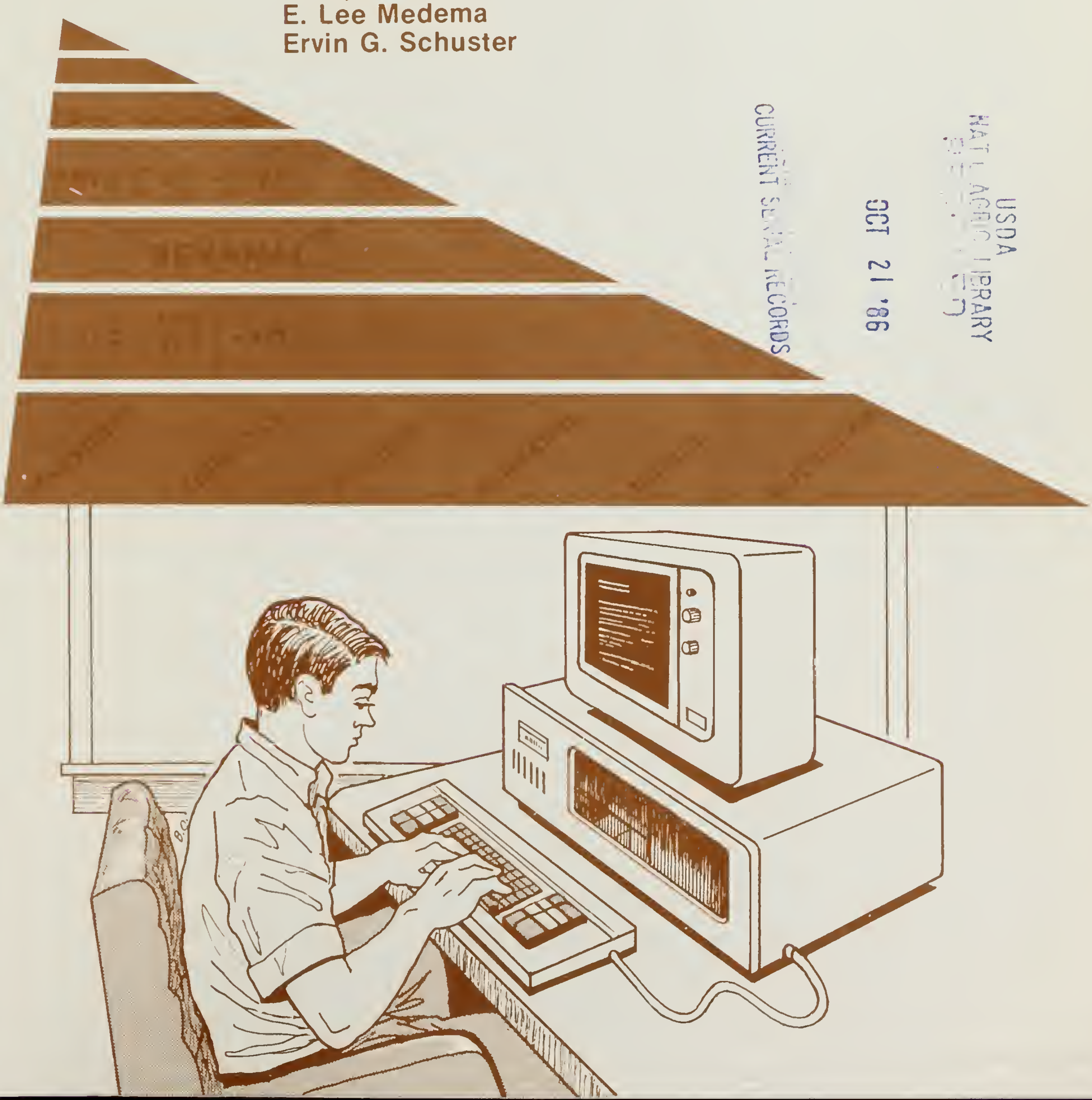
Intermountain Research Station

General Technical Report INT-211

October 1986

User's Guide to CHEAPO II—Economic Analysis of Stand Prognosis Model Outputs

Joseph E. Horn
E. Lee Medema
Ervin G. Schuster



THE AUTHORS

JOSEPH E. HORN is a forest statistician, Boise Cascade Corporation, Boise, ID. He received a B.S. degree in botany from Oregon State University in 1976 and an M.S. degree in forest resources in 1982 from the University of Idaho where he also served as a research associate. His principal research activities have dealt with modeling individual tree growth for a variety of forest types.

E. LEE MEDEMA is an associate professor, Department of Forest Resources, College of Forestry, Wildlife and Range Sciences, University of Idaho, Moscow. He received academic training at the University of Washington, including a Ph.D. in forest economics in 1977. His research includes investment analysis program development and application (domestic and international), analysis of economic impact assessments, and analysis of forest policy issues.

ERVIN G. SCHUSTER is a research forester and Project Leader of the Economics Research Work Unit, Intermountain Research Station, Forestry Sciences Laboratory, Missoula, MT. He received academic training at the University of Minnesota and Iowa State University, where he received a Ph.D. in forest economics in 1971. His research includes modeling of timber harvests, measurement of nontimber outputs, and analysis of economic impact assessments.

RESEARCH SUMMARY

Since its introduction in 1979, CHEAPO, a computer-based economic analysis program, has allowed users of the Stand Prognosis Model to evaluate silvicultural alternatives from an economic point of view. Subsequent modifications to the Prognosis Model have rendered CHEAPO obsolete. This user's guide covers a new computer model, CHEAPO II, which is compatible with version 5.1 of the Prognosis Model and expands its economic analysis capabilities.

CHEAPO II allows users of the Prognosis Model to analyze the economic aspects of management treatments projected by the latest version of the Prognosis Model and its associated extensions: the Regeneration Establishment Model and the Douglas-fir Tussock Moth Outbreak Model. CHEAPO II has been designed to allow users flexibility in the types of stands that can be analyzed (existing or regenerated), the types of management regimes analyzed (even- or uneven-aged), the types of economic analyses undertaken (present net value, soil expectation value, and present net value plus), and the economic decision criteria that can be used (present net value, benefit-cost ratio, and rate of return). CHEAPO II represents a powerful analytical tool for analyzing proposed investments in stand management alternatives.

From a user's standpoint, CHEAPO II functions very much like the old CHEAPO and its input format was patterned after the Prognosis Model. CHEAPO II uses information from two data files—one generated by the Prognosis Model and the other provided by the user. The user-created data file amounts to a set of instructions to CHEAPO II through keyword records. These keyword records instruct CHEAPO II as to: (1) which of the three types of economic analyses is to be performed; (2) the costs and revenues associated with a variety of silvicultural treatments; and (3) how output and reports are to be presented. CHEAPO II execution ends with printing of tabular output displaying the set of instructions given CHEAPO II, economic analysis results, a listing of the undiscounted cash-flow, and optional stand tables. This user's guide describes the CHEAPO II model, the model's input data requirements, and the model's tabular output.

Intermountain Research Station
324 25th Street
Ogden, UT 84401

CONTENTS

User's Guide to CHEAPO II—Economic Analysis of Stand Prognosis Model Outputs

Joseph E. Horn
E. Lee Medema
Ervin G. Schuster

INTRODUCTION

Forest managers utilizing the timber Stand Prognosis Model (Stage 1973; Wykoff and others 1982) to project and evaluate silvicultural alternatives have found the computer model CHEAPO (Computerized Help for the Economic Analysis of Prognosis Model Outputs) (Medema and Hatch 1982) to be a useful tool for analyzing the economic implications of alternatives. CHEAPO users include public (State and Federal) and private (forest industry and nonindustrial) forest managers. Although CHEAPO could be used with any computerized timber yield projection system, its application has been limited to the Prognosis Model, the system with which it was designed to interface.

Since CHEAPO's introduction in 1979, the Prognosis Model has been modified and several analytical extensions have been added, including the ability to model stand regeneration (Ferguson and Crookston 1984) and potential outbreaks of the Douglas-fir tussock moth (Monserud and Crookston 1982). These Prognosis Model extensions have rendered the original version of CHEAPO obsolete. Yet the need to assess economic implications of management options still remains.

This user's guide describes a new economic analysis model called CHEAPO II. The model enables users to undertake economic analyses utilizing the current version (version 5.1) of the Prognosis Model and its associated extensions. CHEAPO II is more than a simple update required by modifications to the Prognosis Model. New features and analytical capabilities have been added, including cost and revenue assignment by tree diameter size class, analysis of uneven-aged management regimes, and output of stand table information. Development of CHEAPO II was coordinated with extensions to the Prognosis Model. Additionally, the user-specified data requirements for CHEAPO II are comparable to those of the original CHEAPO. The user already familiar with CHEAPO should have little difficulty adapting to CHEAPO II.

This user's guide is intended to be easily understood and of practical use to general forest managers. Throughout this manual, however, a certain level of prior knowledge is assumed. First, **it is assumed that the user is familiar with the Prognosis Model.** CHEAPO II was specifically designed to interface with version 5.1 of the Prognosis Model, the Regeneration Establishment Model, and the Douglas-fir Tussock Moth Outbreak Model. Separate user's guides are available for the Prognosis Model (Wykoff and others 1982) and the above extensions (Ferguson and Crookston 1984; Monserud and Crookston 1982). Like CHEAPO, the CHEAPO II model is merely an optional program that may be used in conjunction with the Prognosis Model. This manual is intended to familiarize users only with CHEAPO II, not the Prognosis Model.

Second, it is assumed that the user is familiar with the basic economic techniques of timber stand investment analysis. This manual is not intended to be a primer in economic analysis. CHEAPO II can be a powerful economic analysis tool because the program allows for a great deal of flexibility in specifying economic assumptions underlying the stand analysis. It is possible, however, to incorrectly formulate an economic analysis and yet generate output (albeit incorrect) from the model. It is also possible to formulate a correct analysis and incorrectly interpret the model output. Therefore, a basic understanding of timber stand investment analysis is a prerequisite to the effective use of both this manual and the program itself. Users not familiar with how economic assumptions such as discount rates, timber as capital, and infinite rotation vs. single rotation analyses influence investment decisions and management practices should review these concepts before using CHEAPO II. This information can be found in forest finance, economics, or management texts, including Davis (1966), Duerr (1960), Gregory (1972), Leuschner (1984), and Clutter and others (1983).

The purpose of this user's guide is threefold:

-Describe and explain the economic analysis capabilities of CHEAPO II.

-Describe and explain the input data needed to run CHEAPO II.

-Describe and explain the output (or results) of CHEAPO II.

With these purposes in mind, the next section provides the user with a brief overview of CHEAPO II and its linkage to the Prognosis Model. Subsequent sections describe data input and examples, along with program output examples.

MODEL OVERVIEW

CHEAPO II processes relevant timber yield projections and economic information on forest management alternatives. Timber yield information is provided to CHEAPO II by the Prognosis Model. Economic information is provided by the user. All information is transformed into a comprehensive economic efficiency analysis for a specified planning horizon based on the type of economic analysis specified by the user. The economic analysis results are expressed in terms of traditional investment decision criteria, including present net value (PNV), benefit-cost ratio (B/C Ratio), rate of return (ROR), and more depending on the analysis specified. These can be used to assess the economic desirability and rank the economic attractiveness of alternative management programs.

Investment Decision Criteria

Investment decision criteria are alternative indexes used to assess the finanacial desirability of individual investments and to compare the relative desirabilities of alternative investments.

CHEAPO II uses three basic criteria—present net value is expressed in dollars; benefit-cost ratio is expressed as a unitless number; rate of return is expressed as a percentage. Present net value is the present (or discounted) value of benefits minus the present value of costs. PNV is also known as present net worth. The benefit-cost ratio is the present value of benefits divided by the present value of costs. Rate of return is the discount rate that makes the present value of the benefits equal to the present value of the costs, that is, where the present net value equals zero. ROR is the average annual net compound growth rate over the investment's life, also known as the internal rate of return and the return on investment. Identified by an iterative search procedure within CHEAPO II, the ROR is independent of any user-specified discount rate.

The investment criterion used should depend on the purpose of the analysis and may also depend on management or organizational policy. For example, present net value is the preferred criterion for use in the USDA Forest Service. An individual investment is economically desirable if (1) the present net value is greater than 0.0, (2) the benefit-cost ratio is greater than 1.0, or (3) the rate of return is greater than some minimum acceptable (or guiding) rate of return on investment.

In analyzing a single investment alternative, the decision criteria provide consistent results. That is, the present net value, benefit-cost ratio, and rate of return criteria will all consistently portray a given alternative as being either economically desirable or undesirable. In comparing two or more "mutually exclusive" investment alternatives, however, the three decision criteria may yield conflicting results. For example, present net value and benefit-cost ratio may indicate that one alternative is preferred but rate of return may indicate another. Alternative investments are said to be mutually exclusive if investment in one precludes investment in the other. For example, the decision to undertake one management treatment on a particular stand precludes undertaking an alternative treatment. Either treatment may be adopted, but not both. The reason for the potential inconsistency of the decision criteria regarding the comparison of mutually exclusive investment alternatives results from differences in how each criterion handles (1) differences in the size of the investments, (2) differences in investment time horizons, and (3) assumptions regarding what is done with intermediate revenues generated during the investment time horizons. For further explanation, refer to Wippern (1974), Mishan (1971), or Mills and Dixon (1982).

Data and Analyses

CHEAPO II input is in two forms. The first is a special data file made available to CHEAPO II by the Prognosis Model. Projected stand statistics, removals, and a list of the management treatments specified in the Prognosis Model become the data elements comprising this CHEAPO II input file. The second input file contains economic information and related assumptions supplied by the user. The user must also instruct CHEAPO II as to the type of economic analysis desired. Analyses can pertain to management regimes on either existing forest stands or on essentially bare land—recently clearcut land intended for regeneration. The user specifies one of three types of economic analysis for CHEAPO II to perform: (1) present net value analysis (PNVANAL), (2) soil expectation value analysis (SEVANAL), or (3) present net value plus analysis (PNVPLUS). Analyses, implications, and results associated with each type of analysis are different (table 1).

Table 1.—Economic analysis information displayed for three types of economic analyses

	Economic analysis information displayed					
	Finite time horizon[1]				Infinite time horizon	
	Present value benefits and costs	Investment criteria				
Type of analysis		PNV	B/C ratio	ROR	SEV	PNVPLUS
PNVANAL	yes	yes	yes	yes	no	no
SEVANAL	yes	yes	yes	yes	yes[1]	no
PNVPLUS	yes	yes	yes	yes	no	yes[2]

[1]Information provided for each cycle.
[2]Information provided for repeatable management regime portion.

Present Net Value Analysis.—PNVANAL computes the value of the discounted benefits and discounted costs for each cycle of a management regime projected by the Prognosis Model. Present net value analysis is the least complicated form of analysis available in CHEAPO II. PNVANAL is designed to discount the benefits and costs associated with a projected management regime and to calculate a present net value, benefit-cost ratio, and rate of return for each cycle of the regime. The time horizon of this investment analysis technique is finite, dictated by the length and number of cycles specified in the Prognosis Model projection. Hence, PNVANAL ignores any future growth of the existing timber crops or of additional timber crops beyond that time horizon.

Given the time limitations above, PNVANAL can be applied to an analysis of either existing stands (fig. 1) or clearcut stands intended for regeneration (fig. 2). PNVANAL is useful not only for comparing the economic efficiency of alternatives, but also for determining the economically optimal harvest age of the stand for one rotation. The harvest age can be defined by any one of the investment decision criteria: PNV, B/C Ratio, or ROR. Because each of these decision criteria are calculated and displayed for the end of each cycle and the beginning inventory year, the user can easily identify the year at which the selected criterion has the largest value.

Figure 1.—Finite investment horizon for an existing stand.

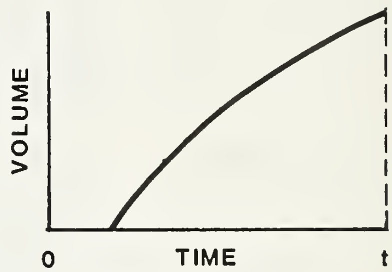


Figure 2.—Finite investment horizon for a regenerated stand.

Soil Expectation Value Analysis.—SEVANAL evaluates management options over an infinite time horizon. Soil expectation value (SEV) is also known as land expectation value. In CHEAPO II, the **soil expectation value analysis is applicable only to recently clearcut areas intended for regeneration that are to be managed on an even-aged management basis.** The stand regeneration extension (Ferguson and Crookston 1984) feature of the Prognosis Model allows the user to project stand establishment; the soil expectation value feature in CHEAPO II is tailored for this type of Prognosis Model projection. A typical purpose of using the soil expectation value analysis is to determine an optimum rotation age that recognizes all future rotations. Another use of SEVANAL is to compare management regimes over an infinite time horizon.

SEVANAL is basically a present net value model that seeks to identify the largest present net value of land devoted to timber production in perpetuity. As with any productive asset, the value of land (bare land) devoted exclusively to timber production is derived from the value of the products it produces (crops of trees). Therefore, rather than determining the present net value over a finite investment horizon, SEVANAL determines the present net value of an infinite series of identical timber crops (fig 3). This specific present net value is soil expectation value. The soil expectation value can be thought of as the present net value decision criteria applied to an infinite time horizon.

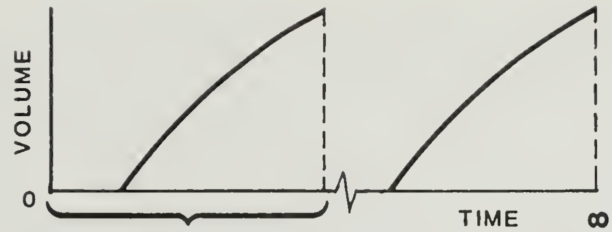


Figure 3.—Infinite investment horizon for a regenerated stand.

Given a specified management regime, CHEAPO II calculates the soil expectation value at the end of each cycle. Hence, the management regime that starts at the beginning of the Prognosis Model projection and ends with each cycle is treated as an infinitely repeatable management regime. By varying the management treatments on subsequent Prognosis Model projections, the user can identify the management regime and rotation age that produces the greatest soil expectation value among the alternatives analyzed. The soil expectation value analysis also gives the PNV, B/C Ratio, and ROR associated with a finite time horizon that concludes at the end of each Prognosis Model cycle.

Present Net Value Plus Analysis.—PNVPLUS was included in CHEAPO II to allow users to analyze investments using uneven- or even-aged management regimes that start with existing forest stands and that cover an infinite time horizon. This analysis became appropriate when the Regeneration Establishment Model (Ferguson and Crookston 1984) was incorporated into the Prognosis Model. The Regeneration Establishment Model added flexibility in the type of management regimes that can be projected, especially in uneven-aged management situations. But, such flexibility increases the complexity in the analytical procedures of an economic analysis.

Starting with an existing stand, the user may want to analyze the discounted benefits and costs only over the finite time horizon specified in the Prognosis Model projection. If this is the case, PNVANAL should be used. The user, alternatively may decide to undertake an economic analysis of a management strategy that begins with an existing stand, goes through a transition period, and continues with a management regime that is repeatable over an infinite time horizon. In this case, PNVPLUS should be used. When the condition of a repeatable management regime has been achieved (as specified by the user), it is presumed to continue ad infinitum, and the resulting PNVPLUS calculations include these yields along with their associated benefits and costs. The repeatable management regime may encompass uneven-aged management (fig. 4) or even-aged management treatments (fig. 5).

It is important to note that the repeatable management regime should be justifiable on strong biological grounds. PNVPLUS within CHEAPO II can repeat **any** management regime ad infinitum, regardless of its biological feasibility. Therefore, only those repeatable regimes that are biologically realistic should be analyzed by the PNVPLUS option of CHEAPO II.

The PNVPLUS analysis is a composite of PNVANAL and SEVANAL. During the transition period (figs. 4 and 5) the analysis is handled as in PNVANAL. Costs and revenues are simply discounted to investment year zero. The repeatable management regime portion of the problem is handled like a SEVANAL in that the present net value is calculated as an infinite series of

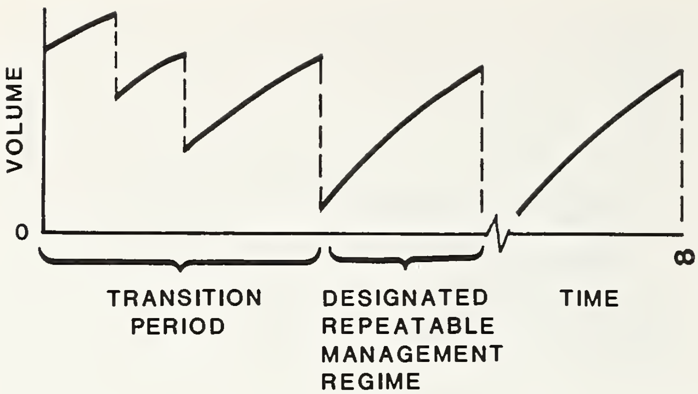


Figure 4.—Infinite investment horizon for an existing stand with an uneven-aged management regime.

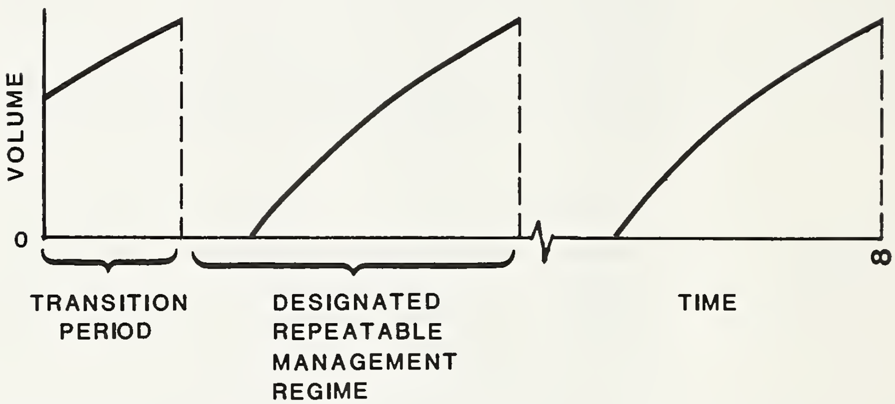


Figure 5.—Infinite investment horizon for an existing stand with an even-aged management regime.

identical rotations. Similar to SEVANAL, PNVPLUS also provides PNV, B/C Ratio, and ROR measures associated with a finite investment time horizon concluding at the end of each cycle. Also, like SEVANAL, the present value of the PNVPLUS results is an extension of the PNV selection criteria to an infinite investment horizon.

Prognosis Model-CHEAPO II Interface

Discussion of the Prognosis Model-CHEAPO II interface covers three topics: (1) model linkages, (2) the timing of future stand projection and economic analysis events, and (3) multiple stand analyses. It is important to understand these topics and the associated nomenclature, analytical options, and analytical limitations of the model interface.

Model Linkage.—Unlike Prognosis Model extensions, CHEAPO II does not interact dynamically with the Prognosis Model. The Prognosis Model, however, can be instructed to generate and "store" a special output file of stand projection information. This stored file will be retrieved and used as an input by CHEAPO II. Because this file is stored external to the Prognosis Model, it is possible to either execute CHEAPO II and the Prognosis Model in the same run or to "save" the special file generated by the Prognosis Model and run CHEAPO II at a later time.

The actual procedures used to store, retrieve, and save this special file are dependent on the job control language of the specific computer system used. Because the actual procedures vary from installation to installation, they are not discussed here.

Timing of Events.—The time perspective of a CHEAPO II economic analysis is a present-day analysis of the costs and revenues associated with silvicultural treatments planned for the future. Although treatment costs may provide valuable information and insights into an actual or hypothetical analysis starting with bare land, past expenses are "sunk" costs for an existing stand and, hence, irrelevant to decisions about its future. **The relevant investment time perspective starts today (investment year zero)** and continues into the future. Therefore, the timing of future events projected by the Prognosis Model is critical to the discounting calculations in CHEAPO II. All calculations for the investment decision criteria in CHEAPO II are based on the values of costs and revenues discounted to the present (investment year zero).

The time element in the Prognosis Model is initiated by a user-specified **inventory year**. The user also controls the length of the Prognosis Model projection by specifying the number and length of growth **cycles** to be projected. The Prognosis Model, given initial stand conditions and starting with the inventory year specified, projects stand development and displays stand output information at the end of each growth projection cycle.

For example, assume the actual (today's) date and inventory year are 1985 and stand information is desired to be displayed every fifth year (a cycle length of five) for four cycles. Each cycle in the Prognosis Model projection would encompass a 5-year period and would extend for 20 years, as shown in figure 6. Stand information would be displayed and dated 1985 for the initial stand conditions, and 1990, 1995, 2000, and 2005 for the projected stand conditions. Stand information and dates are part of the special file created for CHEAPO II by the Prognosis Model. Similarly, silvicultural treatments that were specified using the Prognosis Model and their corresponding date of occurrence are part of that special file. Therefore, the user need not be concerned with the actual transfer of information, but should be aware of the interpretation of dates by CHEAPO II.

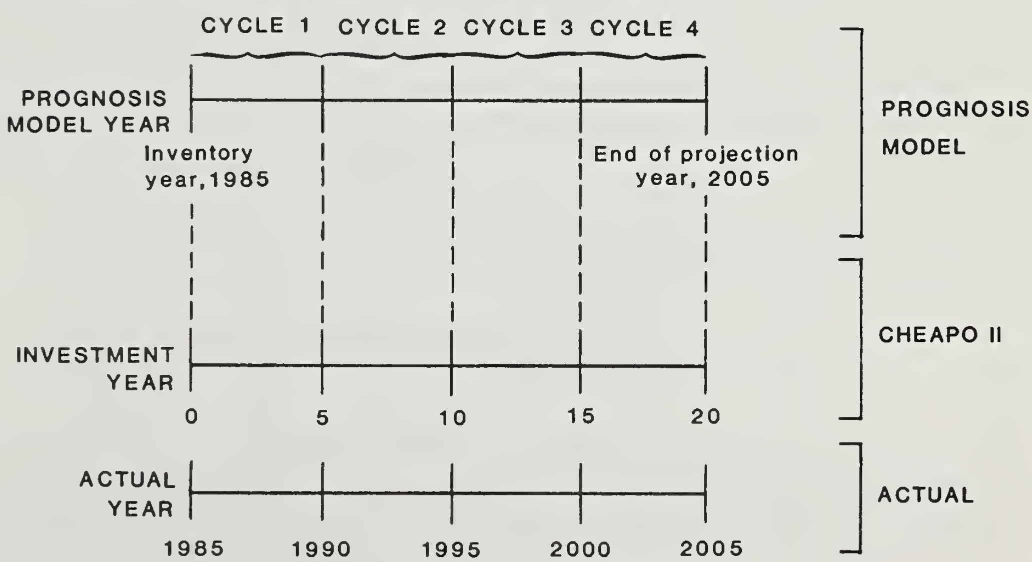


Figure 6.—Prognosis Model—CHEAPO II time interface.

Consider the easiest case first, that of analyzing an existing stand for a finite time horizon using PNVANAL. The inventory year (1985 in the fig. 6 example) is interpreted by CHEAPO II to be the beginning year (investment year zero) of the investment analysis time horizon. Any costs or revenues occurring in this year would reflect present (today's) values and would not need to be discounted. But any projected cost or revenues after this inventory date would be discounted by CHEAPO II. For example, if costs and revenues were projected to occur at the beginning of the second cycle, they would be discounted to the present by CHEAPO II for 5 years. CHEAPO II is not as much concerned with the actual date (such as 1990) specified as with the length of time (number of years) that elapses between the occurrence of cost and revenue producing treatments and the initial inventory year specified in the Prognosis Model projection (investment year zero). In PNVANAL, the length of the Prognosis Model projection determines the length of the investment time horizon.

In the SEVANAL and PNVPLUS analysis types, however, an infinite time horizon is used for CHEAPO II calculations. This is accomplished by treating the Prognosis Model projection, or a portion of the projection, as an infinite series of repeatable management regimes. SEVANAL is assumed to start with bare land in investment year zero (fig. 6) and treats the Prognosis Model projection to the end of the first cycle as a repeatable management regime. CHEAPO II also treats the projection to the end of the second cycle as a repeatable management regime, and so on until the end of the last cycle. Therefore, using the example in figure 6, a soil expectation value would be calculated for a perpetual series of rotation ages of 5 years (1985-90), 10 years (1985-95), 15 years (1985-2000), and 20 years (1985-2005). PNVPLUS starts with an existing stand at investment year zero and treats the portion of the Prognosis Model projection occurring after the user-specified transition period as an infinitely repeatable management regime.

An additional difference can occur between the Prognosis Model projection time horizon and the CHEAPO II investment time horizon. In CHEAPO II, the user has the option of analyzing an existing stand as if the analysis started from bare land. This is accomplished by "tricking" CHEAPO II regarding the occurrence dates for events (fig. 7) in the Prognosis Model projection. For example, assume the actual date and the stand inventory year for an existing

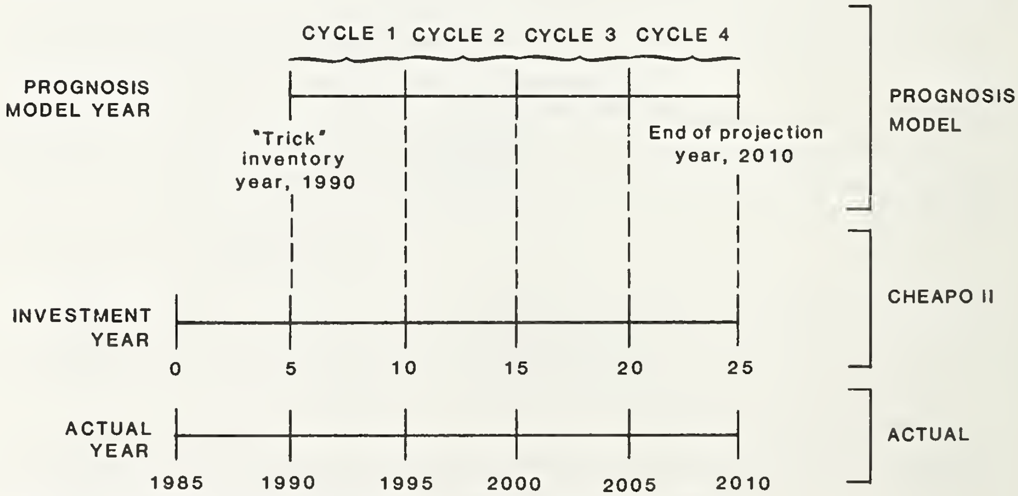


Figure 7.—Prognosis Model—CHEAPO II time interface adjustment to undertake a soil expectation value analysis on an existing stand.

stand are 1985 and the inventoried stand is the result of previous activities—site preparation and planting 4 years ago on a site that was clearcut 5 years ago (hence bare land). The user could "trick" CHEAPO II into conducting an analysis that effectively starts from bare land by (1) entering the inventory year as 1990 in the Prognosis Model projection; (2) dating the planting and site preparation costs to occur in 1986; and (3) specifying 1985 as the year of stand establishment, beginning of the investment time horizon.

Multiple Analyses.—Multiple analyses are possible with the Prognosis Model and CHEAPO II. In explaining this phase of the interface, it is necessary to review some terms. A **stand** is the initial set of tree records used in a Prognosis Model projection. The initial **tree records** are either entered by the user or are generated by the Prognosis Model. A **stand projection** is the growth and yield information generated by the Prognosis Model for a stand based on management treatments specified by the user. The Prognosis Model is capable of projecting as little as a single stand with a single management regime or multiple projections ("stacked projections") on a single computer run. Multiple (stacked) projections can include projections of: (1) several management regimes for a single stand, (2) a single management regime for each of several stands, or (3) several management regimes for several stands (fig. 8).

CHEAPO II has been designed to accommodate the above Prognosis Model flexibilities. CHEAPO II can undertake a single economic analysis for a single projection or a single economic analysis for each of the multiple (stacked) projections. Additionally, CHEAPO II has the capability to undertake multiple economic analyses for each projection, whether applied to a single projection or stacked projections (fig. 8). Instructions on how these analyses are actually accomplished are discussed in a later section.

DATA INPUT

This section pertains to the information that is entered in the user-specified CHEAPO II input file. When the Prognosis Model is executed, the user must specify (1) the existing stand conditions that are to be projected, (2) the length of the projection (including the number and duration of each cycle), and (3) the management treatments desired. The Prognosis Model then projects the stand over the specified period and generates a summary file for use by CHEAPO II. But the user must provide additional information instructing CHEAPO II how to conduct the economic analysis.

For each treatment specified in the Prognosis Model management regime, CHEAPO II requires additional information that includes identifying:

1. Stand treatments undertaken.
2. Unit of measure for each treatment.
3. Current (today's) costs or revenues for undertaking each treatment.
4. Current (today's) cost or revenue value rate changes (in either real or nominal terms).
5. Duration of each value rate change.
6. Discount rate (in either real or nominal terms, but same as 4 above).

The user must specify desired numerical values for economic variables. All variables are automatically set equal to zero (the default value incorporated into CHEAPO II) **and must be changed to be nonzero.** Tree volume units of measure in CHEAPO II differ from those used in the Prognosis Model. In CHEAPO

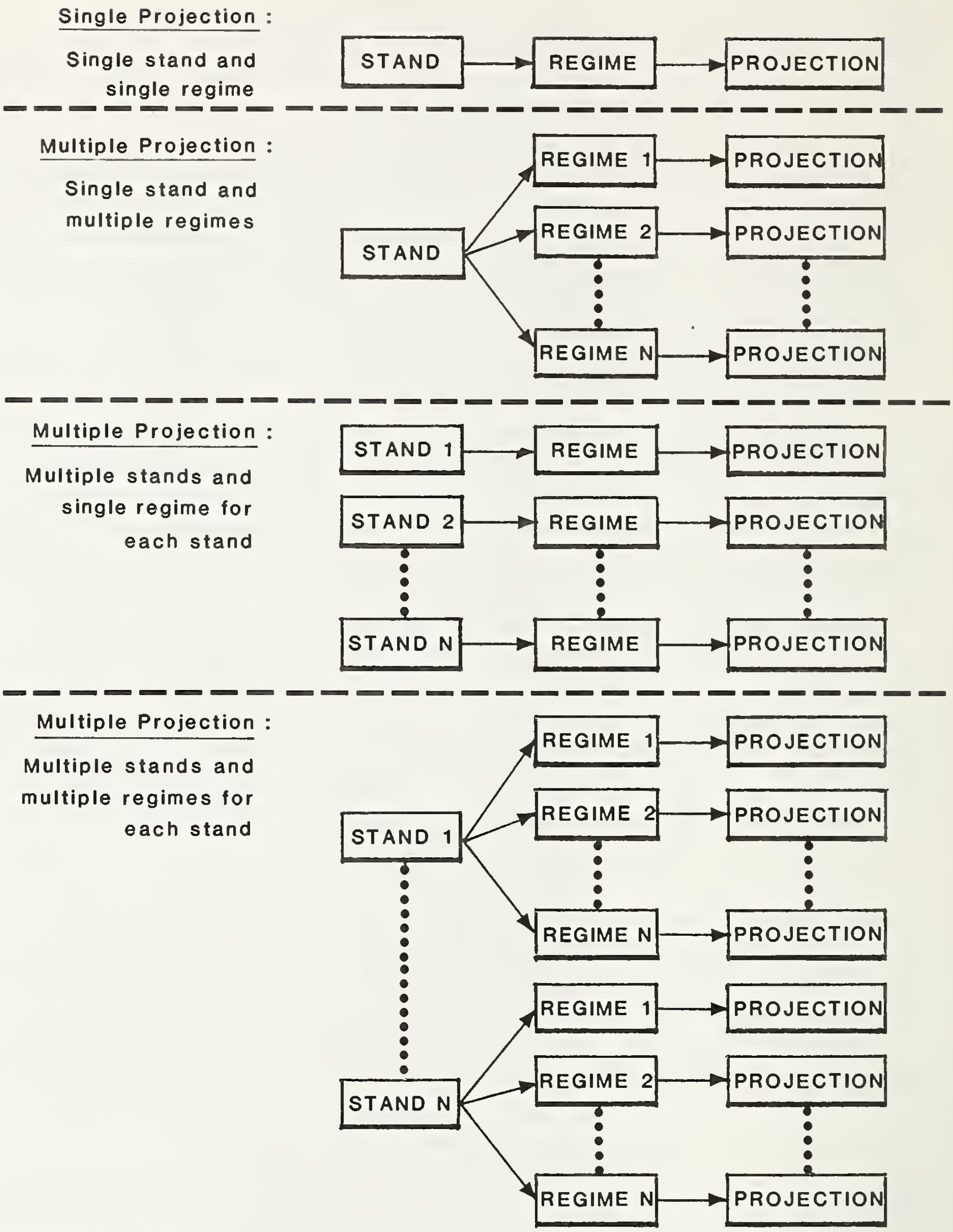


Figure 8.—Multiple projection options.

II, the board foot measure (BF) is recorded in units of **thousand board feet** and the cubic foot measure (CF) is recorded in units of **hundred cubic feet**; in Prognosis, both are recorded in units of one board foot or cubic foot.

Input Format

Users communicate all information used by CHEAPO II through a keyword system. The general keyword system is similar to that used by the original CHEAPO model and the Prognosis Model. Data and instructions are communicated to CHEAPO II in lines of formatted data called records. There are two types of records: keyword records and supplemental data records.

There are four types of formatted data fields: keyword, units/species, numeric, and continuation fields. The keyword field is eight columns long,

beginning in column 1 of the keyword record. The units/species field is a two-column field beginning in column 10. The units/species field is used to designate species or unit of analysis, as appropriate. Numeric fields 1-6 are used for entering economic analysis data and analysis control information, such as prices or costs, dates of occurrence, diameter size class specifications, value rate changes, and durations of value rate changes. **The continuation field is used to designate that additional data occur on a second, or supplemental record immediately following the keyword record.** This is accomplished by **entering the character C anywhere** in the 10-column field. The supplemental data record includes six additional numeric fields.

The column and field designations for both records are summarized as follows:

Record	Field	Columns	Column justification
Keyword	Keyword	1-8	Left-justified
	Units/Species	10-11	Left-justified
	Field 1	12-20	Right-justified if decimal
	Field 2	21-30	points are not used. Any-
	Field 3	31-40	where within the field if
	Field 4	41-50	decimal points are used.
	Field 5	51-60	
	Field 6	61-70	
	Continuation	71-80	Anywhere in field.
Supplemental	Field 7	12-20	Right-justified if decimal
	Field 8	21-30	points are not used. Any-
	Field 9	31-40	where within the field if
	Field 10	41-50	decimal points are used.
	Field 11	51-60	
	Field 12	61-70	

CHEAPO II keywords fall into four categories: analysis-type, economic assumptions, program execution, and output control. Each keyword will be introduced and its function defined in the course of describing how the model works. For reference, appendix A contains an index to pages on which keyword descriptions are given.

Analysis-type Keywords

There are three types of economic analyses available in CHEAPO II. The purpose of the analysis-type keyword is to indicate to CHEAPO II which type of economic analysis the user wants to perform. **Only one analysis-type may be specified for each individual economic analysis.** If more than one type is specified in the keyword file, the first one encountered is used. The following analysis-type keywords and their associated fields are available to CHEAPO II users:

PNVANAL Requests a present net value analysis. Cash-flows are discounted to the beginning of the stand projection based on user-specified assumptions concerning costs, revenues, and discount rate. PNV, B/C Ratio, and ROR measures are calculated for each cycle beginning with the inventory year specified on the Prognosis Model projection and ending with the year corresponding with the end of the last cycle projected. PNVANAL encompasses a finite investment time horizon. Investment year zero is the inventory year.

Units/Species: Unit of measure for volume assignment. BF=1,000 bd ft, CF=100 ft^3.
... Default value is CF.

Fields 1-12: Blank.

SEVANAL Requests soil expectation value analysis. SEV is calculated at each cycle with the assumption that the management treatments projected through previous cycles are repeatable into the future to an infinite time horizon. PNV, B/C Ratio, and ROR measures are calculated at each cycle, to the end of the Prognosis projection, as if the corresponding investment age were the rotation length. SEVANAL is for all rotations and, hence, encompasses an infinite investment time horizon.

Units/Species: Unit of measure for volume assignment. BF=1,000 bd ft, CF=100 ft^3.
... Default value is CF.

Field 1: Year of stand establishment (such as 1990). This is year zero for the investment time horizon and may precede the inventory year used in the Prognosis Model projection.
... Default value is the inventory year specified in the Prognosis Model.

Fields 2-12: Blank.

PNVPLUS Requests present net value plus analysis. A transition period leading to the repeatable management regime is implicit in PNVPLUS. PNVPLUS, however, includes the value of all future repeatable management regimes and encompasses an infinite investment time horizon. PNV, B/C Ratio, and ROR measures are calculated for each cycle through the transition period and the first rotation of the repeatable management regime as if the corresponding investment age were the rotation length.

Units/Species: Unit of measure for volume assignment. BF=1,000 bd ft, CF=100 ft^3.
... Default value is CF.

Field 1: Year designation corresponding to the date at which the repeatable management regime **begins**.
... Default: if no year is specified, the entire analysis reverts to PNVANAL.

Field 2: Year designation corresponding to the date at which the repeatable management **ends**.
... Default: if no year is specified, the entire analysis reverts to PNVANAL.

Fields 3-12: Blank.

Precautions have been built into CHEAPO II in an attempt to avoid a "double counting" of costs or revenues associated with the treatments that occur at the cycle boundary between the end of the transition period and the beginning of the repeatable management regime (figs. 4 and 5). Both occur at the same cycle boundary, a common date. The precaution is that **thinning and harvest costs along with associated harvest revenues are included as part of the transition period. All other activities are considered part of the repeatable management regime**. For example, if the year 2000 were designated as the beginning of

the repeatable management regime (it must be a cycle boundary) and a seed-tree harvest were scheduled on that date, then all revenues and costs associated with the removal operation would be included in the transition period. These costs and revenues would not be considered as part of the repeatable management regime; that is, they would not be repeated. But costs and revenues associated with all other treatments that occurred in the year 2000 would be included in the repeatable management regime. These distinctions are made on the basis of keywords.

Economic Assumption Keywords

The purpose of the economic assumption keywords is to enter the economic parameters (costs, revenues, discount rate, and so on) associated with the management treatments projected. Keywords to specify economic assumptions make up the majority of the keywords used in CHEAPO II. Economic assumption keywords provide information about (1) tree removal treatments, (2) cost items, (3) revenue items, and (4) the discount rate. Value rate changes and the duration of the value rate changes can be specified for all cost and revenue items. Costs can be assigned for thinnings, harvests, annual costs, special costs, and costs associated with management activities projected by the regeneration and Douglas-fir tussock moth outbreak extensions of the Prognosis Model. Revenues can be assigned for special revenues and for tree removals interpreted to occur at the beginning of the user-specified year. All **costs and revenues used should be entered as the actual values existing in the base year (investment year zero)** of the investment time horizon.

In computing the analytical results, CHEAPO II automatically interprets cost items to have negative values and revenue items to have positive values. Therefore, **signs (negative or positive) associated with these values are not to be routinely included.**

The costs and revenues entered should reflect any economies of scale that are present for the acreage size of the proposed investment. The Prognosis Model and, hence, CHEAPO II **conduct all analyses on a per-acre basis.** Whether the actual stand is more than or less than 1 acre, it is assumed that the acre analyzed reflects a representative composite of the stand and treatments proposed. Certain actual costs and revenues, however, may be subject to economies of scale. In site preparation, for example, the larger the area treated, the lower the per-acre costs. The user must take this into account when entering cost and revenue values.

Tree Removal Treatments.—Tree removal treatments are defined and specified by differentiating between a precommercial thinning operation (with a user-specified cost) and other thinning and harvest operations (with user-specified costs and revenues). The key analytical difference between these operations is that a **precommercial thinning operation is always a net cost, whereas other thinning and harvest operations may be a net cost or net revenue**, depending on the mix of costs and tree sizes, numbers, and values. The differentiation is accomplished by the user specifying **average tree size and volume standards** for removals.

Average tree size is expressed using the quadratic mean diameter of the trees removed. A quadratic mean diameter is defined as the diameter of the tree of average basal area. Quadratic mean is used rather than the simple, arithmetic mean because it is a more stable estimate of average tree size.

When a removal operation occurs and (1) the quadratic mean diameter of the trees removed is less than the user-specified diameter **and** (2) the total volume removed is less than the user-specified volume, CHEAPO II interprets the

removal as a precommercial thinning operation (a cost). If not, the removal is interpreted as another thinning or harvest operation, which may or may not be commercial.

These standards are entered with the keyword and field parameters as follows:

THINSPEC Average tree size and volume standards for defining tree removal treatments are entered. If the quadratic mean diameter of trees removed is less than the diameter specified, and the total volume removed is less than the volume specified, CHEAPO II interprets the removal to be a precommercial thinning operation (a cost).

Units/Species: Blank.

Field 1: Enter average tree size expressed as a quadratic mean diameter limit (such as 10.4).
... Default is 0.0 inch.

Field 2: Enter the volume-per-acre removal limit in the unit of volume defined on the analysis-type keyword record.
... Default is 0.0 volume units as specified on the analysis-type keyword record.

Fields 3-12: Blank.

In many cases the user will probably have a good idea from past experience as to whether the removals scheduled in the Prognosis Model projection are precommercial thinning or other thinning and harvest operations. In cases where the user has no such past experience, the Prognosis Model may have to be executed and results evaluated prior to specifying tree size and/or volume standards.

Only one of the selection criteria may actually be needed to differentiate between types of operations. For example, suppose the user knows that the minimum amount of volume per acre that needs to be removed in order to justify a harvest is 2.0 M bd ft. The user can then specify an artificially high diameter limit (such as 99.9 inches) and the 2.0 M bd ft breakpoint. In this case, only the board foot volume standard effectively acts as the cutoff level to distinguish a precommercial thinning from a commercial operation. Because the diameter limit is never met, all harvests that remove more than 2.0 M bd ft per acre will be treated as a commercial operation. Also, if only a diameter breakpoint is known, the user can specify an artificially large volume limit (such as 999 M bd ft). In this case only the diameter breakpoint will be relevant. Of course, the user who understands the breakpoints for these criteria can use both. Artificially low values for both criteria will ensure that all removals are treated as commercial operations, and artifically high values will ensure that all removals will be treated as precommercial thinnings.

Thinning and Harvest Costs.—Thinning and harvest costs can be specified using two types of keywords for each treatment. Thinning costs are assigned to precommercial thinning operations as identified by the THINSPEC keyword. Harvest costs are assigned to other thinning and harvest operations only. Keywords specify whether the costs are to be treated as fixed or as variable. **Fixed costs do not vary with the amount of timber removed. Variable costs change with the amount removed.** For example, machinery setup costs would usually be fixed costs, but felling/bucking costs would be variable. The first two keywords are used to designate fixed treatment costs. The second two keywords

are used to designate variable costs. Fixed costs are always expressed on a per-acre basis. Variable costs can be expressed as per thousand trees or per unit of volume.

Up to six diameter size classes with different variable costs may be specified. There is no allowance for differences in variable costs by species. It is not necessary that all diameter size classes have the same unit of measure. For example, costs for small-sized materials might be expressed on a per-thousand-trees basis while large-sized material may be expressed per M bd ft. **Up to six diameter size class limits may be entered, each to the nearest whole inch.** If more than six classes are specified, only the first six are recognized by CHEAPO II. Fixed and variable costs are entered with keyword and field parameters as follows:

FIXTCOST	Fixed precommercial thinning cost assignment on a per-acre basis.	
FIXHCOST	Fixed harvest cost assignment on a per-acre basis.	
	Units/Species:	Blank (understood on a per-acre basis).
	Field 1:	Current (today's) per-acre value for fixed cost (such as 197.15).
	Field 2:	Blank.
	Fields 3-12:	Value rate changes and durations.
THINCOST	Variable precommercial thinning cost assignment.	
HARVCOST	Variable harvest cost assignment.	
	Units/Species:	Enter TA=1,000 trees; BF=1,000 bd ft; and CF=100 ft^3. . . . Default measure is CF.
	Field 1:	Current (today's) per-unit value of cost (such as 19.75).
	Field 2:	Smallest diameter size class to which costs apply. Up to six diameter size classes may be used—each diameter size class specified requires a separate THINCOST or HARVCOST record.
	Fields 3-12:	Value rate changes and durations.

Annual Costs.—Annual costs can be specified as one of three types: overhead, forest protection, and administration. Annual costs are fixed costs, expressed on a per-acre basis. Keywords and field parameters are as follows:

OVERHEAD	Overhead costs.	
FPROTECT	Forest protection costs.	
ADMINIST	Administration costs.	
	Units/Species:	Blank (always on an annual, per-acre basis).
	Field 1:	The current (today's) value of annual costs on a per-acre basis (such as 7.62).
	Field 2:	Blank.
	Fields 3-12:	Value rate changes and durations.

NOTE: The three specified classes of annual costs are all handled by CHEAPO II in the same way. If the user has an annual cost that does not correspond to one of the three types specified above, the cost can be entered as if it were one of these types of headings, but the heading used to label output would have to serve as a surrogate for the correct heading. **The user must keep track of this label alteration.**

Special Costs.—Special costs, unlike annual costs, can occur at any user-specified point in time. For example, planting activities not associated with the regeneration establishment extension could be entered as a special cost. **Up to 10 individual special costs can be entered.** If more than 10 are entered, only the first 10 will be recognized.

Each special cost is entered on its own keyword record. If the year of occurrence for a special cost is outside the analysis time horizon, it is ignored. When the year of occurrence is not at the beginning of a cycle and the unit of measure specified is other than per acre, the number of trees per acre or volume measure used to calculate the cost will be based on the **stand conditions at the beginning of the cycle after scheduled tree removals.** When the year of occurrence is at the beginning of a cycle, the stand conditions after scheduled tree removals are used. If the analytical procedures just described portray incorrectly the special cost activity, the resulting calculations will also be incorrect. This problem can be remedied if the user enters special costs on a per-acre basis.

If more than 10 special costs are needed, additional cost values can be specified by assigning negative values to special revenues. But only up to a total of 10 special revenues can be used. Note, however, that **by including costs as a negative revenue, the resulting benefit-cost ratio will be incorrect.** The keyword and field parameters are as follows:

SPECCOST	Special cost.	
	Units/Species:	Unit to which value applies (AC=per acre; CF=100 ft^3; BF=1,000 bd ft; TA=1,000 trees per acre). . . . Default measure is AC.
	Field 1:	Current (today's) value of cost per unit.
	Field 2:	Year of occurrence.
	Fields 3-12:	Value rate changes and durations.

Prognosis Model Extensions.—CHEAPO II currently recognizes two Prognosis Model extensions: the Douglas-fir Tussock Moth Outbreak Model and the Regeneration Establishment Model. Keywords used by CHEAPO II to link economic information with the management treatments available in the extensions are the same keywords used in the extensions.

There are currently six management activities that can occur when Prognosis Model extensions are evoked that also can be analyzed by CHEAPO II. Costs can be assigned to these events and a cost will apply when an event occurs within the Prognosis Model projection. **A total of 20 separate occurrences of these events can be analyzed.** If more than 20 are encountered, the excess is ignored by CHEAPO II.

Douglas-fir Tussock Moth Outbreak Model.—The Douglas-fir Tussock Moth Outbreak Model (Monserud and Crookston 1982) allows for three treatment keywords, two corresponding to viral and the other to chemical control applications. The cost of each treatment can be specified for use in the economic analysis when the Outbreak Model is evoked. The keywords refer to specific treatment options available within this Prognosis Model extension. For a description of these treatments, see Monserud and Crookston (1982, pp. 16-18). **Treatment costs are always expressed on a per-acre basis.** For the economic analysis, the keywords and field parameters are as follows:

NPV2	Nuclear polyhedrosis virus treatment applied in phase II.
NPV3	Nuclear polyhedrosis virus treatment applied in phase III.

CHEMICAL Chemical control.

Units/Species: Blank (understood on a per-acre basis).

Field 1: Current (today's) per-acre cost of the treatment.

Field 2: Blank.

Fields 3-12: Value rate changes and durations.

Regeneration Establishment Model.—The Regeneration Establishment Model (Ferguson and Crookston 1984) allows for three treatment keywords that can be specified as cost items in the economic analysis. The keywords refer to three specific treatment options available within the Regeneration Establishment Model—MECHPREP, BURNPREP, and PLANT. For a description of the keywords, see Ferguson and Crookston (1984, pp. 10-12). **Costs associated with MECHPREP and BURNPREP must be expressed on a per-acre basis, and costs associated with PLANT may be expressed either on a per-acre or per-thousand-trees-planted basis.** For the economic analysis, the keywords and the field parameters are as follows:

MECHPREP Site preparation using mechanical scarification.

BURNPREP Site preparation using burning.

PLANT Planting.

Units/Species: Unit to which value applies (AC=per acre; TA=1,000 trees per acre).
. . . Default measure is AC.

Field 1: Current (today's) per-acre cost of the treatment.

Field 2: Blank.

Fields 3-12: Value rate changes and durations.

In the Regeneration Establishment Model, the user has the flexibility to specify the percentage of the stand to be treated by burning and/or mechanical scarification. The single acre representing the stand can then be divided into percentages burned, scarified, or left untreated. **CHEAPO II will compute a weighted per-acre cost for these treatments, based on the percentage of the area in each treatment.** Therefore the per-acre costs entered in the MECHPREP and BURNPREP keyword records should reflect costs of treating the entire acre.

Harvest Revenues.—Revenues associated with a commercial thinning or with harvest operations can be entered for **up to six diameter size classes per species.** The user should pay particular attention to correctly matching cost and revenue items, especially when revenue is construed as stumpage value. Diameter size class limits are entered to the **nearest whole inch.** Trees are grouped by diameter size class, and the revenue associated with each species size class combination is applied in computing revenues. If more than six size classes are entered for any species only the first six will be used. Each of the six diameter size classes per species specified requires a separate keyword record. **The user must specify appropriate lower diameter limits for each diameter size class.** Diameter limits can be arranged in any order in the record file: ascending, descending, or mixed. CHEAPO II will sort and order them.

The following is an example of how diameter size classes are determined. If two diameter classes (8-inch and 10-inch) are specified for a species, two revenue keywords would be used. The revenue record corresponding to the 8-inch diameter class limit would apply to all trees 8 to 10 inches in diameter. Correspondingly, the 10-inch diameter class revenue record would apply to all trees 10 inches and larger. A tree at the diameter size class boundary is included in the larger diameter class.

The keyword and field parameters are as follows:

REVENUE — Revenue assignment for tree removals.

Units/Species:	Species code (see species codes in appendix B). . . . Default species is OT. *NOTE:* Also see appendix B for instructions on modifying the species code list with revenue assignments.
Field 1:	Current (today's) value per unit for revenues. The value should be expressed in the same unit of volume measure indicated on the analysis-type keyword record (such as BF or CF).
Field 2:	Smallest diameter size class to which the revenue applies.
Fields 3-12:	Value rate changes and durations.

Special Revenues.—Special revenue is the revenue counterpart to the special costs keyword. Special revenues can occur at any user-specified point in time. **Up to 10 special revenues can be entered.** If more than 10 are entered, only the first 10 will be recognized. Like special costs, more than 10 special revenues can be entered by "tricking" CHEAPO II; additional revenues can be entered by treating them as negative special cost values. Nevertheless, only a total of 10 special costs can be used. **As in the case of special costs, this convention will result in an incorrect B/C Ratio.** If the year of occurrence for a special revenue is outside the analysis time horizon, it is ignored. When the year of occurrence is not at the beginning of a cycle and the unit of measure specified is other than per acre, the number of trees per acre or volume measure used to calculate the revenue will be based on the **stand conditions at the beginning of the cycle after scheduled tree removals.** When the year of occurrence is at the beginning of a cycle, the stand conditions after scheduled tree removals are used. The keyword and field parameters are as follows:

SPECREVN — Special revenue.

Units/Species:	Unit to which value applies (AC=per acre; CF=100 ft^3; BF=1,000 bd ft; TA=1,000 trees per acre). . . . Default measure is AC.
Field 1:	Current (today's) value of revenue per unit.
Field 2:	Year of occurrence.
Fields 3-12:	Value rate changes and durations.

The Discount Rate.—Another economic assumption keyword assigns the annual discount rate, the annual rate of compound interest used in all present value calculations. The discount rate used can be expressed in either real or nominal terms. From a computational standpoint, CHEAPO II treats nominal and real discount rates identically. The user is solely responsible for correctly making the distinction. **A nominal discount rate includes inflation as a component; a real rate has the inflation component removed.** Interest rates observed in most everyday occurrences are nominal; they include an inflationary component. Nominal rates include interest rates paid on savings accounts, home mortgages, money market accounts, and so on. The methodology for eliminating the inflationary component from a nominal rate to obtain real rate is as follows:

$$r = \left[\frac{1 + n}{1 + i}\right] - 1.0$$

where

r = the annual real discount rate (in decimal form)

n = the annual nominal discount rate (in decimal form)

i = the annual rate of inflation (in decimal form).

A measure of the rate of inflation can be derived from any number of indexes used to measure inflation, including the Producer Price Index, the Consumer Price Index, or the Gross National Implicit Price Deflator. For a further discussion of these indexes and computational procedures, see Gunter and Haney (1984). **Only one discount rate can be applied per analysis.** If more than one discount rate is entered, the first one encountered is used. The keyword and field parameters are as follows:

DISCOUNT Discount rate to be used in economic analysis.

Units/Species:	Unit to which discount rate applies (RE=real; NO=nominal). ... Default measure is blank. ... Note: Discount rate code is used to label output only and does not affect computations.
Field 1:	Discount rate as a percentage (such as 5.55).
Fields 2-12:	Blank.

Value Rate Changes and Durations.—Cost and revenue levels may change over time with changes in economic markets and conditions. Such changes are referred to as value rate changes and are usually measured relative to the general level of prices. For example, if the value of a particular item increases faster than the general level of prices, it is said to be reflecting a "real" value change. **Up to a total of five different value rate changes and durations can be specified for each cost and revenue item. Value rate changes may be positive** (increasing values) or negative (decreasing values).

Value rate changes are entered as percentages. Durations are entered in whole years. If fractional years are entered, the fractional component is ignored. A duration field left blank, or entered as 0 or 999, is interpreted to be infinity. If no value rate changes are specified, the original value entered is interpreted to remain constant over time.

Like the discount rate, value rate changes can be expressed in either real (inflation is netted out) or nominal (includes inflation) terms. The user, however, must be consistent in the use of nominal or real discount and value rate changes. **Mixing real and nominal rates is an incorrect analytical procedure.** For example, CHEAPO II cannot interpret a difference between a real and a nominal rate for discounting and value rate changes. If the user specifies a discount rate in nominal terms and value rate changes in real terms, CHEAPO II cannot recognize this procedural inconsistency and the resulting output will be analytically incorrect. Moreover, if the user specifies a nominal discount rate, a value rate change must be specified for every cost and revenue item, at least reflecting the inflationary component of the nominal discount rate.

Care should be taken when specifying rate durations with the PNVPLUS and SEVANAL analysis-types. With these two types of analysis, the discounted value of individual rotations or cutting regimes must be recalculated by CHEAPO II one at a time until rate durations become constant. Only then can

CHEAPO II correctly apply an infinite series calculation to remaining rotations or cutting periods. **Unrealistically long and/or complex value rate change combinations could greatly increase computing time.**

Each cost and revenue may have up to five rate/duration combinations specified in numeric fields 3-12. In all cases, the first two rate/duration combinations are specified in fields 3-6. Additional rates can be specified by entering a C in the continuation field and three additional rate/duration combinations on the supplemental record in fields 7-12. **If a negative rate is to be specified, the percentage rate is simply preceded by a negative (−) sign, without space between it and the rate.** The negative sign uses one of the available columns. If a positive rate is to be specified, a plus (+) sign is not necessary. In all cases, the keyword field, units/species field, and numeric fields 1 and 2 are used to define the cost or revenue information to which the value rate changes and durations apply.

Field parameters are as follows:

Record	Field	Content
Keyword	Keyword:	Already used
	Units/Species:	Already used
	Fields 1 & 2:	Already used
	Field 3:	1st value rate change
	Field 4:	Duration of 1st rate
	Field 5:	2d value rate change
	Field 6:	Duration of 2d rate
	Continuation:	Continuation designation
Supplemental	Field 7:	3d value rate change
	Field 8:	Duration of 3d rate
	Field 9:	4th value rate change
	Field 10:	Duration of 4th rate
	Field 11:	5th value rate change
	Field 12:	Duration of 5th rate

Sensitivity Analysis.—The final economic assumption keyword is for conducting a sensitivity analysis. Given a specified management regime for a stand, the Prognosis Model projects the stand through time. If an economic analysis is undertaken, the user specifies analysis instructions by entering appropriate keyword records and relevant keyword parameters. These parameters should reflect, as accurately as possible, the current and perceived future market conditions the user faces in undertaking the proposed investment. In terms of a sensitivity analysis, the above parameters are referred to as a "base case" analysis. Given the Prognosis Model projection and the CHEAPO II economic assumptions specified, the user will obtain economic analytical results.

It is often useful to determine how "sensitive" the base case analytical results are to the economic assumptions specified. For example, if a relatively small change in an economic assumption greatly alters the analytical results, the analysis is said to be highly sensitive to the assumption. In such cases, greater care should be taken in making sure the assumption is accurate.

Furthermore, because investment analyses necessitate projections of future events, users are subject to all of the uncertainties of forecasting. In an attempt to obtain a range of possible investment results, it is often useful to undertake an analysis based on "optimistic" assumptions and one based on "pessimistic" assumptions in addition to the base case analysis. A sensitivity analysis may be used to accomplish this task.

A sensitivity analysis is initiated by the SENSANAL keyword. Information to be changed is entered on applicable economic assumption keyword records immediately following the SENSANAL keyword record. Given the changes specified, CHEAPO II recalculates and displays the additional analytical results. **Because the new record in the sensitivity analysis replaces previously specified data, all fields on the record being modified must be reentered.**

The user may test the sensitivity of any one or any combination of the economic assumptions specified in the base case analysis, with the exceptions of diameter limits, year of occurrence, and analysis type. There is no maximum number of changes that can be made in any given sensitivity analysis, and there is no limit on the number of individual sensitivity analyses that can be undertaken. But the effects of each successive sensitivity analysis on the base case assumptions are cumulative. That is, **once an assumption has been changed by a sensitivity analysis, the change remains in effect for all subsequent sensitivity analyses, unless again changed.** All sensitivity changes remain in effect within a single analysis, but once a new analysis is initiated (as in multiple projections or multiple analyses discussed later), all previously specified sensitivity changes are canceled and the analysis begins afresh.

The keyword and field parameters are entered as follows:

SENSANAL Sensitivity analysis.
Other fields: Blank.

Program Execution Keywords

Program execution keywords are designed to provide the user with flexibility in the execution of options available in CHEAPO II. When any of these keywords are used, **no information is entered in any other field.**

CHEAPO Unlike Prognosis Model extensions, CHEAPO II does not interact dynamically with the Prognosis Model. It does, however, use special Prognosis Model output as input (Wykoff and others 1982, p. 86). In order to generate this special Prognosis Model output, **the keyword CHEAPO must be included in the Prognosis Model keyword file.** The keyword CHEAPO is a Prognosis Model keyword, not a CHEAPO II keyword.

PROCESS Following a set of economic assumption keyword records, the PROCESS keyword is entered to indicate that economic calculations are to be conducted for a single economic analysis for a single Prognosis Model stand projection. When using the sensitivity analysis feature, **the SENSANAL keyword record follows the PROCESS keyword record for the initial (base case) part of the file. Also, each sensitivity analysis must begin with a SENSANAL keyword record and end with a PROCESS keyword record.**

ENDSTAND When the end of the CHEAPO II keywords for analysis of a particular stand has been reached, the ENDSTAND keyword must be entered. The ENDSTAND keyword results in display of requested stand table information and resets program default values for analysis of additional stands.

REWIND In addition to the ability to analyze several stands in a single job stream, CHEAPO II can do several analyses when processing a single stand by using the REWIND keyword. The REWIND keyword follows the PROCESS and ENDSTAND keywords. Although the user is limited to the economic assumptions that can be

changed for sensitivity analyses, **REWIND allows the user to initiate a new economic analysis, including analysis-type.**

STOP — The last keyword available is the STOP keyword. This keyword signals the end of the input file.

Program Output Keywords

CHEAPO II output is displayed in two types of output tables—economic analysis and stand tables. Some tables are automatically printed; others need to be requested by the user through a keyword record. Variation in table content is controlled through the selection of analysis-type, rate of return and table suppressions, and sensitivity analysis options.

The economic analysis output consists of a series of three tables that are automatically printed by CHEAPO II. Output Table 1—Economic Assumptions for Stand Analysis—provides a listing of the economic assumptions used in the analysis. Output Table 2—Undiscounted Cash Flow Summary—is a chronological listing of the management treatments undertaken and the undiscounted costs and revenues associated with each management treatment. Output Table 3—Economic Analysis Summary—displays the results of an economic analysis.

The output of any of these tables may be suppressed. The keywords to suppress these output tables are:

NOTABLE1 — Keywords to indicate that the table is not to be
NOTABLE2 — output. No information is entered in the fields.
NOTABLE3

If suppressed, the printing of the tables can be later reactivated by using the keywords:

TABLE1 — Keywords to reactivate a suppressed output table.
TABLE2 — No information is entered in the fields.
TABLE3

As discussed earlier regarding SENSANAL changes, the above keywords will remain in effect either until specifically changed or until a new analysis is initiated, at which time the default values are again assigned.

An optional set of tables that produce stand table information, as summarized for use in the economic analysis, can also be requested. Tabular information includes a summary by species and size class for each projection cycle. The units (BF or CF) and size classes displayed are based on the parameters entered on the REVENUE, THINCOST, and HARVCOST keywords. Values are displayed for the stand before removals and for any removals that occur. Only species with trees present during the projection are reported. Stand tables cannot be requested with a sensitivity analysis. But the use of the SENSANAL option does not prevent the user from requesting stand tables from the base case analysis. This optional set of tables will be produced only when the user requests them with the following keyword:

STDTABLE — No information is entered in the fields.

Two keywords are available to control calculation and output display of the rate of return (ROR) for all analysis types. ROR is calculated using an iterative method, starting with a discount rate of 0.0 for each cycle. A large number of iterations will probably be necessary before ROR has been identified. For this reason, ROR calculation can be suppressed and reinitiated by keywords. **The default action for ROR is calculation.** The keywords used to control ROR calculations are:

NOROR	Suppress ROR calculation.
ROR	Reinitiate ROR calculation if previously suppressed.

The last keywords available are used to produce a textual comment section for documentation of individual analysis assumptions. For example, the user may want to describe the specific costs associated with a SPECCOST keyword. Comment text is initiated by the keyword COMMENT and ended by the keyword END. The text appearing between these keywords will be reproduced, verbatim, in the comment section. There are no restrictions to the number or format of text records, except that **comment text must be contained between columns 1 and 72 on each record and that the first three columns cannot contain the word "END" if the fourth column is blank.** If the keyword END is omitted from the keyword file, all subsequent records, including keyword records, will be interpreted by CHEAPO II as being part of the comment text. Multiple sets of comment text can be produced by multiple sets of COMMENT and END keyword records. The comment section output is printed in conjunction with output Table 3—Economic Analysis Summary. The keywords used to control the comment section are:

COMMENT	To indicate the beginning of comment section text.
END	To indicate the end of comment section text.

INPUT FILE EXAMPLES

The following input examples are not exhaustive of the potential combinations of keywords available to the user. They serve merely to illustrate the types of analyses that can be undertaken and various input file manipulations that can be performed. The examples are designed to serve two purposes. The first purpose is to illustrate the input format of the keyword records. The second purpose is to illustrate the recommended ordering of the keyword input file. For some keywords, such as the analysis-type keywords (PNVANAL, SEVANAL and PNVPLUS) and program execution keywords (PROCESS, ENDSTAND, SENSANAL, REWIND, and STOP), specific ordering is necessary. Where particular attention is focused on a keyword or other input feature, it will be highlighted with an arrow.

CHEAPO II File From Prognosis Model

If the user is going to use the Prognosis Model to project a forest stand and then undertake an economic analysis of the simulation using CHEAPO II, it is necessary to enter the keyword CHEAPO in the Prognosis Model input file (exhibit 1). This keyword must be placed before the PROCESS keyword record in the Prognosis Model input file. This keyword instructs the Prognosis Model to create a special output file of the management treatments and yields projected by the Prognosis Model, thus creating an input file to be used by CHEAPO II.

Analysis of a Single Projection

Exhibit 2 illustrates an example input file for a single economic analysis of a single Prognosis Model projection.

Keyword PNVANAL indicates the analysis type and that the units/species designation of species volume measure is to be 1,000 bd ft. Other analysis-type keywords include SEVANAL and PNVPLUS.

The COMMENT and END keyword records indicate the beginning and ending of textual comments. The materials appearing between the keyword records are used to document analysis features.

```
                                         COLUMNS
         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
================================================================================

STDIDENT
EXAMPLE   PROGNOSIS MODEL EXAMPLE FOR CHEAPO II USER'S GUIDE
MGMTID
RUN
NOTREES
STDINFO          18       530                 5         2        30
DESIGN           20         1        99       1         0
INVYEAR        1985
NUMCYCLE          8
ESTAB          1985
MECHPREP       1985       100
PLANT          1985         1       500
PLANT          1985         2       100
STOCKADJ       1985       0.0
END
CHEAPO
PROCESS
STOP
```

Exhibit 1.—The keyword CHEAPO in the Prognosis Model input file.

```
                                         COLUMNS
         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
================================================================================

PNVANAL   BF
COMMENT
   CHEAPOII USER'S GUIDE EXAMPLE

      1) ECONOMIC ANALYSIS TYPE IS PRESENT NET VALUE (PNVANAL)
      2) MECHPREP AND PLANT COSTS ENTERED ON A PER ACRE BASIS
      3) SPECIAL COST IN 1990 REPRESENTS A ONE TIME LAND MANAGEMENT
         COST FOR BRUSH CONTROL SPRAY
END
ADMINIST         2.10
FPROTECT          .50
MECHPREP        50.00
PLANT          250.00
SPECCOST        35.00      1990
HARVCOST  BF    98.00       7.0
REVENUE   L    145.00       7.0       2.0      10.0
REVENUE   L    165.00       9.0       2.0      10.0
REVENUE   WP   180.00       7.0       2.0      10.0
REVENUE   WP   195.00      12.0       2.0      10.0       1.0      10.0 C
                  2.0      10.0       3.0
REVENUE   WP   255.00      15.0       2.0      10.0
COMMENT
      4) ALL ECONOMIC VALUES ARE ASSUMED TO BE IN REAL TERMS
END
DISCOUNT  RE      4.0
STDTABLE
PROCESS
ENDSTAND
STOP
```

Exhibit 2.—Example of an input file to analyze a single projection.

Keywords ADMINIST and FPROTECT indicate an annual cost of $2.10 for administration and $0.50 for forest protection. Both costs are understood to be on a per-acre per-year basis.

Keywords MECHPREP and PLANT indicate mechanical site preparation of $50 per acre and planting costs of $250 per acre. There are several methods for regenerating stands (Ferguson and Crookston 1984). If a stand establishment treatment that incurs a cost is used in the Prognosis Model projection, however, the user must specify this cost by using the appropriate keyword and values in the CHEAPO II input file.

Keyword HARVCOST indicates a harvesting operation cost of $98/M bd ft for all trees greater than or equal to 7.0 inches diameter.

The REVENUE keyword records indicate the values, diameter size class specifications, and the amounts and durations of value rate changes for two species. The first revenue record assigns a value of $145/M bd ft for all western larch removed that have a diameter greater than or equal to 7.0 inches and less than the next diameter size class limit specified. This first revenue record also assigns a value rate change of 2.0 percent per year for 10 years. The revenue value will be increased at 2.0 percent per year for the first 10 years and will remain constant thereafter. The second revenue record assigns a value of $165/M bd ft for all western larch removed that have a diameter greater than or equal to 9.0 inches, and assigns a value rate change of 2.0 percent per year for the first 10 years. This second diameter size class specification for western larch now limits the specification on the first revenue record. Given the presence of the second record, the first record, in effect, assigns a value of $145/M bd ft on those western larch trees removed that have a diameter greater than or equal to 7.0 inches but less than 9.0 inches. The third, fourth, and fifth revenue records assign values for different diameter size classes of white pine. The revenue assignments are as follows: $180/M bd ft for trees 7.0 inches to less than 12.0 inches in diameter; $195/M bd ft for trees 12.0 to less than 15.0 inches; and $255/M bd ft for trees greater than or equal to 15.0 inches in diameter. All three diameter size classes for white pine assign a value rate change of 2.0 percent per year for the first 10 years. The 12.0 to less than 15.0-inch diameter size class, in addition to assigning a 2.0 percent per year value rate change for the first 10 years, also assigns a 1.0 percent per year rate change for the next 10 years (the C indicates the rate changes and durations are continued on a supplemental record), a 2.0 percent per year rate change for the next 10 years, and a 3.0 percent per year value rate change for the remainder of the investment time horizon. (Note: If the analysis-type were SENSANAL or PNVPLUS, the investment time horizon would be infinity.)

The DISCOUNT keyword record establishes the annual discount rate at 4.0 percent and the designation RE indicates a real discount rate.

The STDTABLE keyword record requests an optional set of output tables that produce stand table information.

The PROCESS keyword record indicates that economic analysis calculations are to be done using the information and instructions provided on previous keyword records.

The ENDSTAND keyword record indicates that the end of the input for an individual analysis has been reached.

The STOP keyword record indicates the end of the CHEAPO II input file.

Sensitivity Analysis

Exhibit 3 shows an input file for PNVANAL, including a series of sensitivity analyses.

The SENSANAL keyword record follows the PROCESS keyword record of the base case input file and indicates that a sensitivity analysis is to be undertaken by changing one or any combination of the assumptions specified previously. This example has two different sensitivity analyses. The first sensitivity analysis uses the keyword DISCOUNT to change the discount rate from 4.0 to 6.0 percent. All other base case input file specifications remain the same as originally specified. This sensitivity analysis also uses the keyword NOTABLE2 to suppress the printing of output Table 2—Undiscounted Cash Flow Summary—and NOROR to suppress the calculation of the rate of return.

The keyword PROCESS indicates that economic analysis calculations are to be done and marks the end of the first sensitivity analysis.

```
                                         COLUMNS
         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
================================================================================

PNVANAL  BF
COMMENT
   CHEAPOII USER'S GUIDE EXAMPLE

      1) ECONOMIC ANALYSIS TYPE IS PRESENT NET VALUE (PNVANAL)
      2) MECHPREP AND PLANT COSTS ENTERED ON A PER ACRE BASIS
      3) SPECIAL COST IN 1990 REPRESENTS A ONE TIME LAND MANAGEMENT
         COST FOR BRUSH CONTROL SPRAY
END
ADMINIST        2.10
FPROTECT         .50
MECHPREP       50.00
PLANT         250.00
SPECCOST       35.00      1990
HARVCOST BF    98.00       7.0
REVENUE  L    155.00       7.0        2.0        10.0
REVENUE  WP   190.00       7.0        2.0        10.0
REVENUE  WP   255.00      15.0        2.0        10.0
DISCOUNT RE      4.0
STDTABLE
PROCESS
SENSANAL
COMMENT
   CHEAPOII USER'S GUIDE EXAMPLE -- SENSITIVITY ANALYSIS 1
      1) DISCOUNT RATE 6 PERCENT
END
NOTABLE2
NOROR
DISCOUNT RE      6.0
PROCESS
SENSANAL
COMMENT
   CHEAPOII USER'S GUIDE EXAMPLE -- SENSITIVITY ANALYSIS 2
      1) DISCOUNT RATE 6 PERCENT
      2) PLANTING COSTS $300 PER ACRE
END
PLANT         300.00
TABLE2
ROR
PROCESS
ENDSTAND
STOP
```

Exhibit 3.—Example of a sensitivity analysis input file.

The second sensitivity analysis uses the keyword PLANT to change the cost of planting from $250 to $300 per acre. It also uses the keyword TABLE2 to reactivate the printing of output Table 2—Undiscounted Cash Flow Summary—and the keyword ROR to reactivate the calculation of rates of return. If a table is deactivated or the calculating of rates of return is deactivated, this will be done for all subsequent analyses unless the user reactivates the option. Because the effect of sensitivity analyses on changes in base case economic assumptions is cumulative, the discount rate used in the second sensitivity analysis will be 6.0 percent, reflecting the change made by the first sensitivity analysis.

As before, the keyword PROCESS marks the end of the sensitivity analysis.

The keyword ENDSTAND indicates that the end of an individual economic analysis (including each sensitivity analysis) for a particular stand projection has been reached.

The STOP keyword indicates the end of the CHEAPO II input keyword file.

Analysis of Multiple (or Stacked) Projections

In the output created by the Prognosis Model to be used as an input file for CHEAPO II, the user may indicate the results of more than one Prognosis Model projection. The results of several projections can be "stacked," as previously shown in figure 8. Exhibit 4 shows an example of an input file to undertake a present net value analysis on two separate projections, separated by an ENDSTAND keyword record.

```
                                           COLUMNS
         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
================================================================================
```

STACK NO.1

```
PNVANAL   BF
COMMENT
   CHEAPOII USER'S GUIDE EXAMPLE -- FIRST OF 2 STACKED STANDS

      1) ECONOMIC ANALYSIS TYPE IS PRESENT NET VALUE (PNVANAL)
      2) MECHPREP AND PLANT COSTS ENTERED ON A PER ACRE BASIS
      3) SPECIAL COST IN 1990 REPRESENTS A ONE TIME LAND MANAGEMENT
         COST FOR BRUSH CONTROL SPRAY
END
ADMINIST        2.10
FPROTECT         .50
MECHPREP       50.00
PLANT         250.00
SPECCOST       35.00      1990
HARVCOST BF    98.00       7.0
REVENUE  L    145.00       7.0       2.0       10.0
REVENUE  L    165.00       9.0       2.0       10.0
REVENUE  WP   180.00       7.0       2.0       10.0
REVENUE  WP   195.00      12.0       2.0       10.0       1.0       10.0 C
                 2.0      10.0       3.0
REVENUE  WP   255.00      15.0       2.0       10.0
COMMENT
      4) ALL ECONOMIC VALUES ARE ASSUMED TO BE IN REAL TERMS
END
DISCOUNT RE      4.0
STDTABLE
PROCESS
ENDSTAND
```

STACK NO.2

```
PNVANAL   BF
COMMENT
   CHEAPOII USER'S GUIDE EXAMPLE -- SECOND OF 2 STACKED STANDS

      1) ECONOMIC ANALYSIS TYPE IS PRESENT NET VALUE (PNVANAL)
      2) MECHPREP AND PLANT COSTS ENTERED ON A PER ACRE BASIS
      3) SPECIAL COST IN 1990 REPRESENTS A ONE TIME LAND MANAGEMENT
         COST FOR BRUSH CONTROL SPRAY
END
ADMINIST        2.10
FPROTECT         .50
MECHPREP       50.00
PLANT         250.00
SPECCOST       35.00      1990
HARVCOST BF    98.00       7.0
REVENUE  L    145.00       7.0       2.0       10.0
REVENUE  L    165.00       9.0       2.0       10.0
REVENUE  WP   180.00       7.0       2.0       10.0
REVENUE  WP   195.00      12.0       2.0       10.0       1.0       10.0 C
                 2.0      10.0       3.0
REVENUE  WP   255.00      15.0       2.0       10.0
COMMENT
      4) ALL ECONOMIC VALUES ARE ASSUMED TO BE IN REAL TERMS
END
DISCOUNT RE      4.0
STDTABLE
PROCESS
ENDSTAND
STOP
```

Exhibit 4.—Example for multiple (or stacked) projections.

The keyword ENDSTAND preceded by the keyword PROCESS marks the end of each individual economic analysis, at which time all analysis assumptions revert to default values. **There is no limit to the number of stands that can be stacked.** Because one economic analysis is distinct from the other, it would also be possible to do different analysis-types (PNVANAL on the first projection and SEVANAL on the second projection).

Multiple Analyses for a Single Projection

On any single stand projected, only one analysis-type can be executed by CHEAPO II unless the Prognosis Model-created input file is rewound to be used again by CHEAPO II. Exhibit 5 shows an input file example of two analysis-types being done on a single projection: a present net value analysis and a soil expectation value analysis. Again, separation is accomplished with an ENDSTAND keyword record.

The PNVANAL keyword marks the beginning and the keywords. PROCESS and ENDSTAND mark the end of the present net value analysis.

```
                                             COLUMNS
         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
================================================================================
PNVANAL   BF
COMMENT
   CHEAPOII USER'S GUIDE EXAMPLE -- FIRST ANALYSIS OF 2

      1) ECONOMIC ANALYSIS TYPE IS PRESENT NET VALUE (PNVANAL)
      2) MECHPREP AND PLANT COSTS ENTERED ON A PER ACRE BASIS
      3) SPECIAL COST IN 1990 REPRESENTS A ONE TIME LAND MANAGEMENT
         COST FOR BRUSH CONTROL SPRAY
END
ADMINIST        2.10
FPROTECT         .50
MECHPREP       50.00
PLANT         250.00
SPECCOST       35.00          1990
HARVCOST  BF   98.00           7.0
REVENUE   L   145.00           7.0       2.0       10.0
REVENUE   L   165.00           9.0       2.0       10.0
REVENUE   WP  180.00           7.0       2.0       10.0
REVENUE   WP  195.00          12.0       2.0       10.0       1.0       10.0 C
                 2.0          10.0       3.0
REVENUE   WP  255.00          15.0       2.0       10.0
COMMENT
      4) ALL ECONOMIC VALUES ARE ASSUMED TO BE IN REAL TERMS
END
DISCOUNT  RE     4.0
STDTABLE
PROCESS
ENDSTAND
REWIND
SEVANAL   BF    1985
COMMENT
   CHEAPDII USER'S GUIDE EXAMPLE -- SECOND ANALYSIS OF 2

      1) ECONOMIC ANALYSIS TYPE IS SOIL EXPECTATION VALUE (SEVANAL)
      2) MECHPREP AND PLANT COSTS ENTERED ON A PER ACRE BASIS
      3) SPECIAL COST IN 1990 REPRESENTS A ONE TIME LAND MANAGEMENT
         COST FOR BRUSH CONTROL SPRAY
END
ADMINIST        2.10
FPROTECT         .50
MECHPREP       50.00
PLANT         250.00
SPECCOST       35.00          1990
HARVCOST  BF   98.00           7.0
REVENUE   L   145.00           7.0
REVENUE   L   165.00           9.0
REVENUE   WP  180.00           7.0
REVENUE   WP  195.00          12.0
REVENUE   WP  255.00          15.0
COMMENT
      4) ALL ECONOMIC VALUES ARE ASSUMED TO BE IN REAL TERMS
END
DISCOUNT  RE     4.0
PROCESS
ENDSTAND
STOP
```

ANALYSIS NO.1

ANALYSIS NO.2

Exhibit 5.—Example for multiple analysis types on a single stand.

The keyword REWIND executes the rewinding of the Prognosis Model generated input file. This is the critical keyword record for conducting multiple analyses on a single Prognosis Model projection. The instructions for one analysis precede the REWIND keyword; instructions for the next analysis follow it. There is no limit to the number of analyses that can be conducted on a single projection if the REWIND keyword is used repeatedly. Each set of instructions stands alone, with no carry over of instructions from one analysis to another.

The keyword SEVANAL marks the beginning and the keywords PROCESS and ENDSTAND mark the end of the soil expectation value analysis.

The keyword STOP indicates the end of the input keyword file.

OUTPUT EXAMPLES

CHEAPO II output is displayed in two types of tables—economic analysis tables and stand summary tables. Some of these tables are automatically printed, while others need to be called for by keyword records. Variation in

table content is controlled through selection of analysis-type, rate of return and table suppressions, and sensitivity analysis options.

Economic Analysis Tables

The economic analysis tables are automatically included in CHEAPO II output. Through the use of keywords, these tables may be suppressed or expanded. Economic analysis output consists of a set of three tables. Each table heading is designated by a numerical designation of the table type: Table 1 for economic assumptions for stand analysis, Table 2 for undiscounted cash flow summary, and Table 3 for economic analysis summary. The initial numerical designation of the table type is followed by another numerical designation indicating whether the tabled information refers to the base case analysis (0) or a sensitivity analysis (1=the first sensitivity analysis, 2=the second sensitivity analysis, and so on).

Economic Assumptions for Stand Analysis: Table 1.—Output Table 1 lists the economic parameters used in the analysis. It is useful for keeping track of the parameters specified by the user and for checking that the parameters were entered correctly.

Exhibit 6 illustrates output Table 1-0 for a present net value analysis. The column labeled ITEM is a listing of the analysis-type keywords, economic assumption keywords, and the output control keywords specified in the input file. Program execution keywords are **not** included in this table.

The UNITS column is a listing of the units of measure specified for the corresponding keyword. These include YR (annual), BF (thousand board feet), CF (hundred cubic feet), AC (acre), and TA (per 1,000 trees).

SPECIES lists the species codes specified on the REVENUE keyword records. Species codes listed correspond to those shown in appendix B.

TABLE 1- 0. ECONOMIC ASSUMPTIONS FOR STAND ANALYSIS

				LIMITS			VALUE RATE CHANGES AND DURATIONS			
ITEM	UNITS	SPECIES	DATE	MIN DBH	VOLUME	CURRENT VALUE	% FOR	YEARS	% FOR	YEARS
PNVANAL	BF									
ADMINIST	YR					2.10	.0	0		
FPROTECT	YR					.50	.0	0		
MECHPREP	AC					50.00	.0	0		
PLANT	AC					250.00	.0	0		
SPECCOST	AC		1990			35.00	.0	0		
HARVCOST	BF			7		98.00	.0	0		
REVENUE	BF	L		7		145.00	2.0	10		
REVENUE	BF	L		9		165.00	2.0	10		
REVENUE	BF	WP		7		180.00	2.0	10		
REVENUE	BF	WP		12		195.00	2.0	10	1.0	10
						ADDITIONAL RATE/DURATION			2.0	10
						ADDITIONAL RATE/DURATION			3.0	0
REVENUE	BF	WP		15		255.00	2.0	10		
DISCOUNT						4.00 % REAL				
STDTABLE										

NOTE STAND = EXAMPLE MANAGEMENT ID = RUN

Exhibit 6.—Table 1 output for a present net value analysis.

The column labeled DATE lists the dates as specified on the SEVANAL, PNVPLUS, SPECREVN, and SPECCOST keyword records. The columns labeled LIMITS list diameter and volume specifications. The subcolumn MIN DBH refers to minimum diameter size class specifications. This column is appropriate to REVENUE, THINSPEC, HARVCOST, and THINCOST keyword records. The subcolumn VOLUME refers to minimum volume specifications used with the THINSPEC keyword record only.

The CURRENT VALUE column lists the current values of costs, revenues, and the discount rate specified. This column is appropriate for all of the economic assumption keyword records except for the keyword THINSPEC, which contains no cost or revenue information.

VALUE RATE CHANGES AND DURATIONS is a listing of the value rate changes and their durations specified for each economic assumption. Up to five rates and durations may be used for each economic assumption keyword.

The first group of listings in output Table 1-0 reflects the initial assumptions in the input file. When this listing is complete it is set off by a dotted line. Following this line, the standard identifications that were specified in the Prognosis Model projections are printed. These include the stand and management identifications.

If a sensitivity analysis was undertaken, a new output Table 1-1 would be printed and would include a listing of only the economic assumptions changed from the base case analysis in the first sensitivity analysis (exhibit 7).

The format of output Table 1—Economic Assumptions for Stand Analysis—for a soil expectation value analysis and for a present net value plus analysis is identical to that described above, with minor exceptions. For the soil expectation value analysis, ANALYSIS BASE YEAR: _____ is printed immediately following the SEVANAL keyword and the unit of volume measure specified. This is the year specified on the SEVANAL keyword record to establish the beginning year of the soil expectation value analysis (investment year zero). For the present net value plus analysis, REPEATABLE MANAGEMENT REGIME ASSUMED: _____ TO _____ is printed immediately following the PNVPLUS keyword record and the unit of volume measure specified. These are the years specified on the PNVPLUS keyword record as the beginning and ending dates of the repeatable management regime.

Undiscounted Cash Flow Summary: Table 2.—Economic analysis results are shown in output Table 2 (exhibit 8). They consist of a chronological listing of the management treatments undertaken and the undiscounted costs and revenues associated with each treatment. This shows the actual magnitudes of future undiscounted cash flows (in either real or nominal terms) associated with the management treatments projected.

TABLE 1- 1. ECONOMIC ASSUMPTIONS FOR STAND ANALYSIS

ITEM	UNITS	SPECIES	DATE	LIMITS MIN DBH	LIMITS VOLUME	CURRENT VALUE	VALUE RATE CHANGES AND DURATIONS %	FOR YEARS	%	FOR YEARS
NOTABLE2										
DISCOUNT						6.00 % REAL				

NOTE STAND = EXAMPLE MANAGEMENT ID = RUN

Exhibit 7.—Table 1 output with sensitivity analysis.

TABLE 2- 0. UNDISCOUNTED CASH FLOW SUMMARY

ITEM	ACTUAL CASH FLOWS COST	ACTUAL CASH FLOWS REVENUE	CASH FLOW IF EXISTING STAND IS HARVESTED COST	CASH FLOW IF EXISTING STAND IS HARVESTED REVENUE
MECHPREP COST IN 1985	50.00			
PLANT COST IN 1985	250.00			
ANNUAL COSTS THRU 1985	2.60			
THINNING COSTS IN 1985	.00		.00	
HARVEST COSTS IN 1985	.00		.00	
HARVEST REVENUES IN 1985		.00		.00
SPECIAL COST IN 1990	35.00			
ANNUAL COSTS THRU 1995	26.00			
THINNING COSTS IN 1995	.00		.00	
HARVEST COSTS IN 1995	.00		.00	
HARVEST REVENUES IN 1995		.00		.00
ANNUAL COSTS THRU 2005	26.00			
THINNING COSTS IN 2005	.00		.00	
HARVEST COSTS IN 2005	.00		44.66	
HARVEST REVENUES IN 2005		.00		99.99
ANNUAL COSTS THRU 2015	26.00			
THINNING COSTS IN 2015	.00		.00	
HARVEST COSTS IN 2015	.00		419.84	
HARVEST REVENUES IN 2015		.00		986.82
ANNUAL COSTS THRU 2025	26.00			
THINNING COSTS IN 2025	.00		.00	
HARVEST COSTS IN 2025	.00		1141.58	
HARVEST REVENUES IN 2025		.00		3434.91
ANNUAL COSTS THRU 2035	26.00			
THINNING COSTS IN 2035	.00		.00	
HARVEST COSTS IN 2035	.00		2105.69	
HARVEST REVENUES IN 2035		.00		7762.67
ANNUAL COSTS THRU 2045	26.00			
THINNING COSTS IN 2045	.00		.00	
HARVEST COSTS IN 2045	.00		3212.96	
HARVEST REVENUES IN 2045		.00		12881.04
ANNUAL COSTS THRU 2055	26.00			
THINNING COSTS IN 2055	.00		.00	
HARVEST COSTS IN 2055	.00		4192.76	
HARVEST REVENUES IN 2055		.00		17944.13
ANNUAL COSTS THRU 2065	26.00			
THINNING COSTS IN 2065	.00		.00	
HARVEST COSTS IN 2065	.00		5042.41	
HARVEST REVENUES IN 2065		.00		22014.85

Exhibit 8.—Table 2 output.

The column labeled ITEM is a listing of the management practices undertaken, whether it is a cost or revenue item, and the year (or years) in which the item occurred.

To understand the remaining columns, labeled ACTUAL CASH FLOWS and CASH FLOW IF EXISTING STAND IS HARVESTED, it is necessary to understand the general logic of CHEAPO II computations. CHEAPO II treats the end of each cycle as if it were the end of a rotation. Therefore, the first step CHEAPO II accomplishes is to determine the costs and revenues derived as if the existing stand were harvested. These are the values listed in the column CASH FLOW IF EXISTING STAND IS HARVESTED. Having completed this step, CHEAPO II next lists the cash flow associated with any treatments that were undertaken in the Prognosis Model projection. These are the

values listed in the column ACTUAL CASH FLOWS. The entire cash flow associated with this column is the actual cash flow of all treatments except those harvest treatments associated with the end of a potential rotation. That particular cash flow component is replaced by the IF EXISTING STAND IS HARVESTED cash flow component when CHEAPO II calculates the PNV, B/C Ratio, ROR, and SEV corresponding to that date. The analysis then proceeds to the next cycle.

Economic Analysis Summary: Table 3.—Economic analysis output displayed in output Table 3 consists of the analytical results presented on a cycle-by-cycle basis. The contents of this table depend on the analysis-type chosen. Exhibit 9 is an example of an analysis output Table 3 and the associated comment section for a simple present net value analysis.

The column labeled INVESTMENT YEAR is the same as the YEAR column shown earlier in output Table 2 (exhibit 8). It begins with the inventory year of the Prognosis Model projection and increments time according to subsequent cycle-ending dates.

The column labeled INVESTMENT AGE reflects the number of years that the costs and benefits are discounted to obtain present values. This also reflects the time increments along the investment time horizon. The investment time horizon always begins (investment year zero) with the inventory year of the Prognosis Model projection, unless otherwise specified for a soil expectation value analysis.

The columns labeled PRESENT VALUE, with subheadings of BENEFITS and COSTS, are the discounted value of the benefits and costs if the management regime was implemented up to, and the existing stand was harvested at the end of the cycle. The columns B/C RATIO, PRESENT NET VALUE, and % RATE OF RETURN contain the calculated values for the investment criteria.

TABLE 3- 0. ECONOMIC ANALYSIS SUMMARY FOR PNV ANALYSIS

INVESTMENT		PRESENT VALUE			PRESENT	% RATE
YEAR	AGE	BENEFITS	COSTS	B/C RATIO	NET VALUE	OF RETURN
1985	0	.00	302.60	.00	-302.60	---
1995	10	.00	352.46	.00	-352.46	< 0.0
2005	20	45.63	387.08	.12	-341.45	< 0.0
2015	30	304.25	505.77	.60	-201.52	1.2
2025	40	715.45	620.61	1.15	94.84	4.6
2035	50	1092.30	683.52	1.60	408.78	5.6
2045	60	1224.47	695.61	1.76	528.86	5.6
2055	70	1152.35	661.45	1.74	490.90	5.3
2065	80	955.09	612.31	1.56	342.78	4.8

NOTE STAND = EXAMPLE MANAGEMENT ID = RUN
DISCOUNT RATE = 4.0% REAL

COMMENTS- 0. ECONOMIC ANALYSIS DOCUMENTATION

CHEAPOII USER'S GUIDE EXAMPLE

1) ECONOMIC ANALYSIS TYPE IS PRESENT NET VALUE (PNVANAL)
2) MECHPREP AND PLANT COSTS ENTERED ON A PER ACRE BASIS
3) SPECIAL COST IN 1990 REPRESENTS A ONE TIME LAND MANAGEMENT COST FOR BRUSH CONTROL SPRAY
4) ALL ECONOMIC VALUES ARE ASSUMED TO BE IN REAL TERMS

NOTE STAND = EXAMPLE MANAGEMENT ID = RUN

Exhibit 9.—Table 3 output for a present net value analysis.

The benefit-cost ratio, present net value, and rate of return (unless the keyword NOROR is used to suppress printing rate of return results) are calculated and printed regardless of the analysis type selected.

Exhibit 10 is an example of an output Table 3 for a soil expectation value analysis. The table headings and interpretation of the table entries are the same as those shown earlier for the present net value analysis results (exhibit 9). The exception is that a column SOIL EXPECTATION VALUE is included. The soil expectation value results reflect the present net value of an infinite series of identical rotations for each cycle.

Exhibit 11 is an example of an output Table 3 for a present net value plus analysis. Again, the table headings and interpretation of the table entries are the same as shown earlier for present net value analysis results (exhibit 9). But the PNVPLUS analysis also includes a determination of the present net value of an infinite series of repeatable management regimes where the beginning and ending dates of the repeatable regime are user-specified. Therefore, at the bottom of output Table 3 for the PNVPLUS analysis, the results of this repeatable management are printed. The output includes the beginning and ending dates specified by the user and the analytical results.

TABLE 3- 0. ECONOMIC ANALYSIS SUMMARY FOR SEV ANALYSIS WITH BASE YEAR 1985

INVESTMENT YEAR	INVESTMENT AGE	PRESENT VALUE BENEFITS	PRESENT VALUE COSTS	B/C RATIO	PRESENT NET VALUE	% RATE OF RETURN	SOIL EXPECTATION VALUE
1985	0	.00	302.60	.00	-302.60	---	
1995	10	.00	352.46	.00	-352.46	< 0.0	-1080.95
2005	20	37.44	387.08	.10	-349.65	< 0.0	-641.01
2015	30	239.44	505.77	.47	-266.33	< 0.0	-383.89
2025	40	467.62	620.61	.75	-152.99	2.6	-192.55
2035	50	633.19	683.52	.93	-50.33	3.7	-58.15
2045	60	705.30	695.61	1.01	9.68	4.0	10.97
2055	70	646.93	661.45	.98	-14.52	4.0	-15.33
2065	80	541.08	612.31	.88	-71.23	3.7	-74.34

NOTE STAND = EXAMPLE MANAGEMENT ID = RUN
DISCOUNT RATE = 4.0% REAL

Exhibit 10.—Table 3 output for a soil expectation value analysis.

TABLE 3- 0. ECONOMIC ANALYSIS SUMMARY FOR PNV PLUS ANALYSIS

INVESTMENT YEAR	INVESTMENT AGE	PRESENT VALUE BENEFITS	PRESENT VALUE COSTS	B/C RATIO	PRESENT NET VALUE	% RATE OF RETURN
1985	0	.00	302.60	.00	-302.60	---
1995	10	.00	352.46	.00	-352.46	< 0.0
2005	20	37.44	387.08	.10	-349.65	< 0.0
2015	30	239.44	505.77	.47	-266.33	< 0.0
2025	40	467.62	620.61	.75	-152.99	2.6
2035	50	633.19	683.52	.93	-50.33	3.7
2045	60	705.30	724.13	.97	-18.83	3.9
2055	70	705.30	726.13	.97	-20.84	3.9
2065	80	708.85	729.43	.97	-20.57	3.9
2075	90	728.06	740.71	.98	-12.65	4.0
2085	100	749.75	751.62	1.00	-1.88	4.0
2095	110	765.49	757.60	1.01	7.88	4.0
2105	120	772.34	758.75	1.02	13.59	4.0

THE PRESENT VALUE OF ALL ROTATIONS ASSUMING A REPEATABLE MANAGEMENT REGIME FROM 2045 TO 2105 IS $ 14.00

NOTE STAND = EXAMPLE MANAGEMENT ID = RUN
DISCOUNT RATE = 4.0% REAL

Exhibit 11.—Table 3 output for a present net value plus analysis.

Stand Summary Tables

The stand summary tables are optional output, requested by keywords. The keywords STDTABLE and ENDSTAND must be included in the CHEAPO II keyword input file to produce these output tables.

The first table printed (Stand Summary Table: All Species) is a summary for all of the species projected by the Prognosis Model (exhibit 12). The YEAR column is the same as the year columns in the economic analysis tables. It includes the inventory year and subsequent cycle-ending dates.

The STAND AGE column is the age of the stand as specified in the Prognosis Model.

Subsequent columns list the number of trees per acre, the cubic-foot volumes and board-foot volumes per acre, and the quadratic mean diameter of the stand at the end of each cycle. This information is provided for both the current stand and for any volume removed, as calculated by the Prognosis Model.

The remaining stand summary tables display the same data, but on an individual species basis as in exhibit 13 for western white pine, but with two additional changes. First, the volume printed is in the units specified on the analysis-type keyword record (BF or CF). Second, the volumes are reported in up to six diameter size classes. The diameter classes are those specified on the REVENUE keyword records. Similar tables also are provided if HARVCOST or THINCOST keywords are used. These tables show the distribution of trees or volume (depending on the unit of measure specified) for all species within the diameter classes defined by the HARVCOST and THINCOST keywords.

DISCUSSION

This user's guide to CHEAPO II describes the model's structure and behavior, options and features, and input requirements along with interpretation and control of output. Three points warrant mention:

1. This user's guide avoids discussing computer systems and job control language. These are location-specific topics. Depending on how CHEAPO II is installed at a given location, some of the features discussed in this user's guide may not be available. Users should check with computer system personnel regarding local procedures and limitations.

STAND SUMMARY TABLE : ALL SPECIES

		EXISTING STAND				REMOVALS			
YEAR	STAND AGE	TREES PER ACRE	CUBIC FOOT VOLUME	BOARD FOOT VOLUME	QUAD MEAN DBH	TREES PER ACRE	CUBIC FOOT VOLUME	BOARD FOOT VOLUME	QUAD MEAN DBH
1985	0	.0	.0	.0	.0	.0	.0	.0	.0
1995	10	600.0	.0	.0	1.3	.0	.0	.0	.0
2005	20	424.1	119.9	455.7	3.8	.0	.0	.0	.0
2015	30	379.0	1045.2	4284.1	6.3	.0	.0	.0	.0
2025	40	352.7	2680.3	11648.8	8.5	.0	.0	.0	.0
2035	50	313.8	4744.5	21486.6	10.4	.0	.0	.0	.0
2045	60	269.6	6918.8	32785.3	12.3	.0	.0	.0	.0
2055	70	226.9	8776.4	42783.3	14.0	.0	.0	.0	.0
2065	80	188.2	10352.3	51453.2	15.8	.0	.0	.0	.0

NOTE STAND = EXAMPLE MANAGEMENT ID = RUN

Exhibit 12.—Stand summary table—all species.

STAND SUMMARY TABLE : SPECIES WP

EXISTING STAND VOLUME (BD. FT.)

YEAR	STAND AGE	DBH CLASS 7 TO 12	12 TO 15	15 +
1985	0	.00	.00	.00
1995	10	.00	.00	.00
2005	20	455.70	.00	.00
2015	30	3744.50	487.20	.00
2025	40	6337.40	3627.90	1372.60
2035	50	6902.90	6690.40	7277.40
2045	60	5783.50	7115.50	19040.70
2055	70	4375.70	7024.00	30455.80
2065	80	2857.00	5844.60	41837.70

REMOVAL VOLUME (BD. FT.)

YEAR	STAND AGE	DBH CLASS 7 TO 12	12 TO 15	15 +
1985	0	.00	.00	.00
1995	10	.00	.00	.00
2005	20	.00	.00	.00
2015	30	.00	.00	.00
2025	40	.00	.00	.00
2035	50	.00	.00	.00
2045	60	.00	.00	.00
2055	70	.00	.00	.00
2065	80	.00	.00	.00

NOTE STAND = EXAMPLE MANAGEMENT ID = RUN

Exhibit 13.—Stand summary table—by species and diameter size class.

2. Because CHEAPO II is independent of the Prognosis Model, a given computer installation may have the most recent version of the Prognosis Model available, but only CHEAPO, not CHEAPO II. **The programs must be matched.** It is not possible to execute the old CHEAPO with data generated by the most recent version (5.1) of the Prognosis Model, nor will an old version of Prognosis Model generate a proper CHEAPO II file.

3. Although this guide is intended to allow users to successfully conduct CHEAPO II analyses, it is nevertheless quite elementary. Our experience has been that many more sophisticated and unusual analyses can be accomplished by the experienced user, by thoughtfully manipulating CHEAPO II instructions. We alluded to this when we discussed "tricking" CHEAPO II into performing the desired analyses. Expanded analytical capability of CHEAPO II will be more apparent with increased user familiarity and experience.

REFERENCES

Clutter, Jerome L.; Fortson, James C.; Pienaar, Leon V.; Brister, Graham H.; Bailey, Robert L. Timber management: a quantitative approach. New York: John Wiley and Sons; 1983. 333 p.

Davis, Kenneth P. Forest management: regulation and valuation. 2d ed. New York: McGraw; 1966. 519 p.

Duerr, William A. Fundamentals of forestry economics. New York: McGraw; 1960. 579 p.

Ferguson, Dennis E.; Crookston, Nicholas L. User's guide to the Regeneration Establishment Model—a Prognosis Model extension. General Technical Report INT-161. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1984. 23 p.

Gregory, G. Robinson. Forest resource economics. New York: John Wiley and Sons; 1972. 548 p.

Gunter, John E.; Haney, Harry L., Jr. Essentials of forestry investment analysis. Corvallis, OR: O.S.U. Bookstores; 1984. 337 p.

Leuschner, William A. Introduction to forest resource management. New York: John Wiley and Sons; 1984. 298 p.

Medema, E. Lee; Hatch, Charles R. Computerized help for the economic analysis of prognosis-model outputs: a user's manual. Contribution No. 227. Moscow, ID: University of Idaho, Forest, Wildlife and Range Experiment Station; 1982. 72 p.

Mills, Thomas J.; Dixon, Gary E. Ranking independent timber investments by alternative criteria. Research Paper PSW-166. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station; 1982. 8 p.

Mishan, E. J. Cost-benefit analysis: an introduction. New York: Praeger Publishers; 1971. 364 p.

Monserud, Robert A.; Crookston, Nicholas L. A user's guide to the combined Stand Prognosis and Douglas-fir Tussock Moth Outbreak Model. General Technical Report INT-127. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1982. 49 p.

Stage, Albert R. Prognosis Model for stand development. Research Paper INT-137. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1973. 32 p.

Wippern, Ronald F. Capital expenditure analysis: a summary and overview. Unpublished manuscript copyrighted by the Harvard Business School; 1974. 19 p.

Wykoff, William R.; Crookston, Nicholas L.; Stage, Albert R. User's guide to the Stand Prognosis Model. General Technical Report INT-133. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1982. 112 p.

APPENDIX A: KEYWORD REFERENCE

Type of keyword	Keyword	Page reference
Analysis-type	PNVANAL	11
	PNVPLUS	12
	SEVANAL	12
Economic assumption	ADMINIST	15
	BURNPREP	17
	CHEMICAL	17
	DISCOUNT	19
	FIXHCOST	15
	FIXTCOST	15
	FPROTECT	15
	HARVCOST	15
	MECHPREP	17
	NPV2	16
	NPV3	16
	OVERHEAD	15
	PLANT	17
	REVENUE	18
	SENSANAL	21
	SPCODES	38
	SPECCOST	16
	SPECREVN	18
	THINCOST	15
	THINSPEC	14
Program execution	ENDSTAND	21
	PROCESS	21
	REWIND	21
	STOP	22
Program output	COMMENT	23
	END	23
	NOROR	23
	NOTABLE1	22
	NOTABLE2	22
	NOTABLE3	22
	ROR	23
	STDTABLE	22
	TABLE1	22
	TABLE2	22
	TABLE3	22

APPENDIX B: SPECIES CODES

The species codes used in CHEAPO II are the same as those used in the Prognosis Model. The codes and species are as follows:

Common name	Scientific name	Default input code	Numeric code
Western white pine	*Pinus monticola*	WP	1
Western larch	*Larix occidentalis*	L	2
Douglas-fir	*Pseudotsuga menziesii*	DF	3
Grand fir	*Abies grandis*	GF	4
Western hemlock	*Tsuga heterophylla*	WH	5
Western redcedar	*Thuja plicata*	C	6
Lodgepole pine	*Pinus contorta*	LP	7
Engelmann spruce	*Picea engelmannii*	S	8
Subalpine fir	*Abies lasiocarpa*	AF	9
Ponderosa pine	*Pinus ponderosa*	PP	10
Other species	—	OT	11

Note: *Tsuga mertensiana* (mountain hemlock) is the species used to simulate the growth of all "other species." Numeric codes and letter codes with only one letter must be left-justified in the field.

The user has the option of changing the species codes listed prior to entering any REVENUE keyword records. Species codes are changed using SPCODES keyword records with corresponding supplemental records. Codes are entered left-justified in four column fields beginning in column 11 of the supplemental record. No continuation designation is required. When using SPCODES, all species codes must be entered as they will be used on REVENUE records. This is true for both altered and unaltered codes. For example, if the user wanted to change the western larch species code from L to WL, the necessary input records would be as follows:

```
                                      COLUMNS
         1         2         3         4         5         6         7
123456789012345678901234567890123456789012345678901234567890123456789012
========================================================================
SPCODES
          WP  WL  DF  GF  WH  C   LP  S   AF  PP  OT
```


☆U.S. GOVERNMENT PRINTING OFFICE:1986— 676-039 / 41018

Horn, Joseph E.; Medema, E. Lee; Schuster, Ervin G. User's guide to CHEAPO II—economic analysis of Stand Prognosis Model outputs. General Technical Report INT-211. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station; 1986. 38 p.

CHEAPO II provides supplemental economic analysis capability for users of version 5.1 of the Stand Prognosis Model, including recent regeneration and insect outbreak extensions. Although patterned after the old CHEAPO model, CHEAPO II has more features and analytic capabilities, especially for analysis of existing and uneven-aged stands.

KEYWORDS: silviculture, economic analysis, timber management, investment analysis

INTERMOUNTAIN RESEARCH STATION

The Intermountain Research Station provides scientific knowledge and technology to improve management, protection, and use of the forests and rangelands of the Intermountain West. Research is designed to meet the needs of National Forest managers, Federal and State agencies, industry, academic institutions, public and private organizations, and individuals. Results of research are made available through publications, symposia, workshops, training sessions, and personal contacts.

The Intermountain Research Station territory includes Montana, Idaho, Utah, Nevada, and western Wyoming. Eighty-five percent of the lands in the Station area, about 231 million acres, are classified as forest or rangeland. They include grasslands, deserts, shrublands, alpine areas, and forests. They provide fiber for forest industries, minerals and fossil fuels for energy and industrial development, water for domestic and industrial consumption, forage for livestock and wildlife, and recreation opportunities for millions of visitors.

Several Station units conduct research in additional western States, or have missions that are national or international in scope.

Station laboratories are located in:

Boise, Idaho

Bozeman, Montana (in cooperation with Montana State University)

Logan, Utah (in cooperation with Utah State University)

Missoula, Montana (in cooperation with the University of Montana)

Moscow, Idaho (in cooperation with the University of Idaho)

Ogden, Utah

Provo, Utah (in cooperation with Brigham Young University)

Reno, Nevada (in cooperation with the University of Nevada)